RAYMOND H. BEAMER MEMORIAL ISSUE

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RAYMOND HILL BEAMER
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RAYMOND HILL BEAMER

Dr. Raymond Hill Beamer, for forty years connected with the Department of Entomology of the University of Kansas, was a charter member of the Kansas Entomological Society, its second secretary in 1926, its sixth president in 1931, and a frequent contributor to its Journal through all these years. After his death on November 21, 1957, his colleagues, former students, and friends contributed the necessary funds and manuscripts to make possible this memorial issue of the Journal.

RAYMOND HILL BEAMER

Raymond Hill Beamer was born on a farm in Cherokee County, near Hallowell, Kansas, October 20, 1889.

He received his grade school training in a country school and then attended high school in Columbus, Kansas, twelve miles from his rural home. In those horse and buggy days this was quite a distance and would require at least two hours on the road, too far to live at home and commute each day. Therefore he would usually take the train from Hallowell to Columbus on Sunday evening and someone would have to come for him on Friday evening because there was no westbound train at that time and there was usually farm work to do on Saturdays.

Also living near Hallowell was the Dunbar family, six miles from the Beamers, with the children, Carl and Lucy. They too attended the Columbus high school. Carl was in Raymond's class and Lucy a year behind them. Carl became interested in Raymond's sister Laura and Raymond in Lucy Dunbar, attachments that resulted in marriage after graduation from the University.

The boys were graduated from high school in June, 1909, and entered the University of Kansas that fall. Both of them majored in Geology. The Beamer family moved to Lawrence before the University opened that year. By carrying fifteen or more hours each semester and getting nine hours credit in Invertebrate Zoology during the summer of 1912 for a water life survey[1] Raymond found he needed only seven hours in the spring semester of his senior year for his A.B. degree. In the fall semester he had taken Invertebrate Paleontology, Sociology, Anthropology and Bacteriology (5 hours), the last perhaps because Lucy Dunbar was majoring in Bacteriology.

He liked the Bacteriology and Lucy Dunbar and so in the spring semester he took Dairy Bacteriology (5 hours) and Ethnology (2 hours) for undergraduate credit, and Special Methods of Bacteriology and Serology (5 hours), Bacteriology Journals (1 hour) and General Entomology (3 hours) for graduate credit. The Entomology opened up a new and fascinating world to him and he knew he had found his field. He had been attracted, no doubt, to Geology by its field work and here was another science with life in it and a challenge to his ambidextrous ability in capturing such elusive insects as dragon flies, horse flies and bees.[2]

He had had his undergraduate training in the languages, chemistry, botany, zoology and geology and therefore his graduate transcript shows

[1] This was Raymond's first collecting trip. The party consisted of Ray (Dad) Lindsay in charge and the students: Victor Housholder, Howard Marshbanks, Ittai Luke and Raymond Beamer. Vic Housholder, now of Phoenix, Arizona, writes: "Our transportation consisted of Dad Lindsay's heavy team and lumber wagon with cover and a pair of pinto ponies, and a covered spring wagon owned by the University." They were out thirteen weeks making a water life survey in the southeastern quarter of the state. Some of the counties surveyed were Shawnee, Geary, Marion, Butler, Greenwood, Coffey and Osage "where they seined nearly every pond, ravine, creek, and river in the area."

[2] He was athletically inclined and on the high school baseball team he batted right or left handed to confuse the pitcher and in college played a good game of golf with clubs of either sort. He was captain of the first K.U. Soccer team which played its first intercollegiate game against Baker University at Baldwin, a game I walked down to Baldwin to see. For years he was the champion hand ball player on the faculty.

mostly courses in Entomology, with Problems in Plant Pathology, and one in Vertebrate Paleontology in addition. He received his A.B. degree in June, 1913. He spent that summer on the farm and returned that fall as part-time assistant to work for the M.A. degree in Entomology. In 1914 he was appointed assistant curator of the Francis Huntington Snow Collections which were located at that time on the top floor of the Dyche Natural History Museum.

He spent the summer of 1914 with an Entomological collecting party near Creede, Colorado. The party was led by S. J. Hunter, Head of the department, and consisted of H. B. Hungerford, Assistant Professor, R. H. Beamer, Assistant Curator, and the following students: William Brown, Fred Poos and Alonzo Winsor. On this trip Beamer demonstrated the value of photography in field work. He was a good photographer and the department has been greatly enriched by his efforts through the years.

In September, 1914, Raymond H. Beamer and Lucy Dunbar, who had been graduated from K.U. in June, were married. This was a happy union. They had three children, Imogene, Raymond, Jr., and John (Jack) who, when they were old enough, were taken on the summer collecting trips for Lucy, a fine collector, had had some training in Entomology and liked the field work. She was chief cook and mother of many survey groups, and the children all became experienced collectors. Lucy also did much of the pinning of insects that had to be mounted in the field. The many students who have been on these trips cherish their close friendship with the Beamers and have kept in touch with them since leaving school.

In the summer of 1915 Beamer was in charge of his first entomological survey party. They went to southeastern Kansas. With him were B. P. Young, Walter Wellhouse and Forrest Anderson.

The following summer he continued his survey of southeastern Kansas with H. A. Grutzmacher, Olin Darby and Frank Smith.

He received his M.A. degree in Entomology in 1917. Then came the difficult times of the First World War and the demand for more manpower on the farm. Therefore the Beamers with their baby Imogene went to the Dunbar farm where they were happy hosts to any of us who came collecting insects. Raymond always carried a killing bottle into the field and got quite a few female cicadas attracted by the racket of the Fordson tractor while he was plowing stubble. He took me collecting water bugs nearby and since that southeastern corner of Kansas is in the Lower Austral Zone we got material for a joint paper which we published.

In 1922, with the war emergency over, Beamer returned to his position as Assistant Curator of the Collections and became Assistant Professor of Entomology. He also resumed his work in the graduate school to complete the requirements for the Ph.D. degree, which he received in 1927. He became Associate Professor in 1935, Full Professor in 1939 and Curator of the Francis Huntington Snow Collections in 1949.

In all these years as professor of Systematic Entomology, he taught Insect Taxonomy, inspired and meticulously guided many research students in problems on the Homoptera, and was a productive scholar himself. Some of these students published one or two papers on the Homoptera and others,

for example, Paul W. Oman, Head of Insect Identification and Parasite Introduction Section, U. S. Department of Agriculture and David A. Young, Jr., Department of Entomology, North Carolina State College, are well known homopterists. Beamer's master's thesis on the Oedipodinae (grasshoppers) of Kansas was published and demonstrated his skill in the use of photography. He was at one time interested in the Tabanidae (horse flies) but, as his bibliography will show, most of his research was on the Homoptera.

His skill in making equipment has been much appreciated by staff and students. When locality labels in 3½-point type were difficult to get, he assembled materials and built a press for printing such labels. This press was so satisfactory that other institutions asked him for duplicates and there are now a number of them in use. He was always a good and willing helper on any problem and his generosity of time and worthy counsel in the nursery inspection service of this state will always be deeply appreciated by me. We made many nursery inspection trips together and his keen eye would catch any infestations that occurred.

When we were to have a new Snow Hall he helped me materially with the floor plans for the Entomology floor and the moving of the entomological collections from the Dyche Museum to become a convenient and integral part of the department in the new Snow Hall.

He loved to collect, was untiring and enthusiastic in the field and the best collector I ever knew. He could team up with any expert and come up with more choice specimens of the man's specialty than the man himself. This is why the Francis Huntington Snow Entomological Collections, which he served for so many years, are widely known to contain "a gold-mine of material" for specialists of all orders.

There will be new species bearing the R. H. Beamer collector label turning up from these collections for many many years to come. How many species of insects have been named "beameri" in his honor I do not know, but the following genera perpetuate his name:[3]

Beameria Davis 1934 (in Cicadidae-Homoptera)
Beamerana Young 1952 (in Cicadellidae-Homoptera)
Beamerulus Young 1957 (in Cicadellidae-Homoptera)
Beameromyia Martin 1957 (in Asilidae-Diptera)

And the following species have been brought to my attention by his former students who are at the U.S. National Museum.[4]

COLEOPTERA. Scolytidae: *Hypothenemus beameri* Wood.

DIPTERA. Apioceridae: *Apiocera beameri* Painter. Asilidae: *Cyrtopogon beameri* Wilcox and Martin, *Dioctria beameri* Wilcox and Martin. Bibionidae: *Bibio albipennis beameri* Hardy. Chloropidae: *Oscinella beameri* Sabrosky. Cuterebridae: *Cuterebra beameri* Hall. Dorelaidae: *Tomosvaryella beameri* Hardy. Omphralidae: *Omphrale beameri* Hardy. Sarcophagidae: *Idoneamina beameri* Dodge, *Sarcophaga beameri* Hall. Simuliidae: *Simulium beameri* Stains and Knowlton. Tabanidae: *Chrysops beameri* Brennan, *Pilimas beameri* Philip. Tipulidae: *Hexatoma beameri* Alexander.

[3] See also p. 71 of this issue.
[4] See also pp. 101, 155, 171, 178 and 189 of this issue.

ORTHOPTERA. Acrididae: *Melanoplus beameri* Hebard.

NEUROPTERA. Hemerobiidae: *Sympherobius beameri* Gurney.

HEMIPTERA (HOMOPTERA). Cicadellidae: *Alconeura beameri* Griffith, *Idona beameri* Young, *Collandonus beameri* Ball, *Dikraneuroidea beameri* Lawson, *Erythroneura beameri* Robinson, *Neocoelidia beameri* Oman, *Stirellus beameri* Ball.

HEMIPTERA (HETEROPTERA). Corixidae: *Pseudocorixa beameri* Hungerford, *Pseudocorixa beameroidea* Hungerford. Veliidae: *Velia beameri* Hungerford, *Microvelia beameri* McKinstry, *Rhagovelia beameri* Gould. Saldidae: *Salda beameri* Hodgden. Hebridae: *Hebrus beameri* Porter.

HYMENOPTERA. Eucharitidae: *Orasema beameri* Gehan, *Heterospilus beameri* Rohwer. Mutillidae: *Dasymutilla beameri* Mickel. Vespidae: *Stenodynerus beameri* Bohart. Colletidae: *Colletes beamerorum* Stephen. Megachilidae: *Anthocopa beameri* Michener.

While this list is undoubtedly incomplete, the thirty-seven species in seven orders and twenty-three families is a testimonial to his thoroughness as a collector. Homoptera and Diptera were his favorites but his collecting covered all orders except the Lepidoptera which he would jokingly say "are not insects."

His own research was, for the most part, with the Homopterous families Cicadellidae and Fulgoridae. He published 107 papers and described 563 new species.

H. B. Hungerford

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THE FIELD TRIPS OF R. H. BEAMER

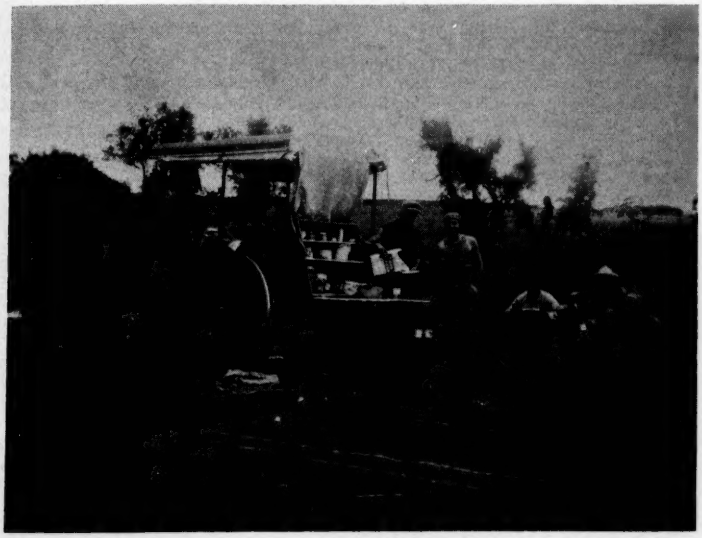
There are published records of the Entomological field trips from 1876 to 1922. The first one 1876-1913 in the University of Kansas Science Bulletin 8:10-15, 1914 (33 trips). The second one 1915-1922 in the University of Kansas Science Bulletin 14:10-11, 1923 (6 trips). Since all the trips from 1923 to 1954 were under Dr. Beamer's direction they should be recorded here.

1923. Kansas survey (Emporia, Lindsborg, Medora), R. H. Beamer with Herb Darby, Clarence Bare and W. J. Brown.
1925. Kansas survey, R. H. Beamer, Howard Deay, Howard Grady, and old Mr. F. F. Crevecoeur, an amateur collector of earlier days.
1926. Western Kansas, on a Vertebrate Paleontology summer field trip with H. T. Martin, for graduate credit.
1927. Southwestern U.S. (Texas, New Mexico, Arizona), R. H. Beamer, P. A. Readio and L. D. Anderson. Mr. and Mrs. Warwick Benedict and Mr. Lyle Stevenson joined the party in Texas for a time.
1928. Texas. The five Beamers, R. H., Lucy (L. D. Beamer on labels), Imogene, Raymond, Jr. and Jack, with J. G. Shaw and A. M. James. At Sonora they met O. G. Babcock, a government entomologist, working on lice affecting the goat industry.
1929. Western United States (Taos and other parts of New Mexico; Flagstaff, Phoenix, and Yuma, Arizona; Lake Tahoe, California; Nevada and Utah). The Beamer five, P. W. Oman, L. D. Anderson and Wm. Lynn. David G. Hall, at Coachella, California, greatly stimulated the party's interest in collecting Diptera.
1930. Southeastern United States (Mississippi, Georgia, Florida to the Keys, back up to Georgia, including Chesser Island in Okefenokee Swamp). The Carolinas, Indiana. The Beamer five, P. W. Oman, L. D. Tuthill and J. O. Nottingham.
1931. Western United States (Colorado, Wyoming, Utah, Oregon including Mt. Hood and Mt. Baker); British Columbia to Vernon; Yellowstone Park; Pingree Park in Colorado for the Rocky Mountain Conference of Entomologists. They obtained Grylloblattids on this trip. The Beamer five, L. D. Anderson, J. O. Nottingham, M. W. Sanderson and H. T. Peters.
1932. Western United States (Arizona and California) depression year—no students. The Beamer five did some collecting with Dr. E. D. Ball.
1933. Western United States (Arizona and California). R. H., L. D., Imogene and Jack Beamer and Jean Russell collected with the E. D. Ball's around Tucson, Arizona, where P. W. Oman joined them for two weeks and Jack Beamer had an emergency appendectomy. In California E. P. Van Duzee joined the party.

1934. Eastern United States (Florida up the coast to Maine and New York). R. H., L. D., Raymond, Jr. and Jack Beamer, Melvin Griffith and A. P. McKinstry. P. W. Oman joined the party for a few days in Maine.

1935. Northwestern United States (California, Oregon and Washington). The Beamer five and Jean Russell. Imogene and Jean were students. P. W. Oman joined them at Sacramento, California for three weeks to Washington.

1936. Southwestern United States (Texas, Arizona, California). They worked both sides of Grand Canyon of the Colorado River from Yuma to the Source. R. H., L. D., and Jack Beamer, Maurice Jackson, Wm. Field and Dale Lindsay.



"Last Supper" just west of Lawrence, 1912, at the end of Beamer's first field trip. Shows the University of Kansas' chuck wagon and Beamer, second from left, pulling the string that crosses the road to the camera.

1937. Survey east and west of 100th Meridian from Kansas to Canada following a conference in Denver, Colorado. Collected two weeks in southwest Colorado. R. H. and L. D. Beamer, Cy. Johnston and L. D. Tuthill. Then did the 100th Meridian survey with Cy. Johnston and H. T. Peters to Red River, Manitoba, Canada. On way back stopped at the University of Michigan Biological Station on Douglas Lake, near Cheboygan, Michigan.

1938. South and West (Arkansas, Texas, New Mexico, Arizona, California). R. H. and L. D. Beamer, R. I. Sailer, D. W. Craik, L. W. Hepner, Jean Russell.

1939. Southern United States (Tennessee, Georgia, Florida). Collected in Great Smokies, Okefenokee Swamp (Billy's Island). R. H. and L. D. Beamer and Jack Beamer now a student, Ed Wegenek, D. E. and A. T. Hardy. Dean Paul B. Lawson was with the party for three weeks, P. W. Oman met the party in Tallahassee, Florida for ten days and L. D. Tuthill joined the party in the Okefenokee Swamp for two weeks.

1940. Southwestern United States (Texas, Arizona, California). East side of Sierras, desert to mountains and back repeatedly. Yosemite, Mono Lake, Utah. R. H. and

L. D. Beamer, D. E. Hardy, L. C. Kuitert, L. J. Lipovsky, E. E. Kanaga. David G. Hall met them at Alamagordo, New Mexico for ten days of collecting. The party returned by way of Rocky Mountain Conference in Colorado.

1941. Southwestern United States (New Mexico, Arizona). R. H. and L. D. Beamer, E. L. Todd, Burton Hodgden, Louis Banker.

1942-43-44-45. No parties in the field. R. H. Beamer spent July, August and September of 1943 in the U.S. National Museum identifying Homoptera.

1946. Eastern States (Cleveland, Ohio, Adirondack and Catskill Mts., New England States, Washington, D.C., Norfolk, Virginia). In Virginia, R. H. and L. D. Beamer got a long series of the rare Saldoida. L. D. Anderson was with them here.

1947. Western States. In salt brush grasshopper country. R. H. and L. D. Beamer, Ann Michener, R. E. Elbel, Roger Olmsted and Herb Wallace.

1948. Southeast United States (Louisiana to Key West) studying shore life. Worked ten days at Archbold Biological Station, Lake Placid, Florida. R. H. and L. D. Beamer, E. L. Todd, H. T. Crowder, B. E. McDermott.

1949. Northwest (Colorado, Utah, Mt. Rainier and Hamilton, Montana) to study spring in the mountains. R. H. and L. D. Beamer and Jimmie White. Cornelius B. Philip, James Brennan, and B. E. McDermott collected with them around Hamilton.

1950. Western States for Hymenoptera, Coleoptera and Membracidae in particular. R. H. and L. D. Beamer, Jerry Rozen, Paul Cook, Jimmie Arnold, and Howard Wright. (While party was in Oak Creek Canyon, R. H. Beamer flew home to his mother's funeral.) C. H. Martin joined the party in Arizona.

1951. Southeastern States (Florida, Subtropical Gardens, State Parks, and Great Smokies). Survey in bark beetles. R. H. and L. D. Beamer, Steve Wood and Roger Price.

1952. Western States to type localities of Hymenoptera. R. H. and L. D. Beamer, W. E. LaBerge, Chen Liang, Al Wolf and Clarence Weiner. They were with the Rozens at Berkeley, California, with Lauren Anderson and P. H. Timberlake at Riverside. Wolf and Weiner left the party at Flagstaff.

1953. In April to South and East Texas for Hymenoptera and Fulgoridae. R. H. and L. D. Beamer.

1954. In April and May to Central and West Texas, Davis Mts., Las Cruces, New Mexico for Hymenoptera. R. H. and L. D. Beamer.

Other collecting trips not recorded above were the following:

1921. Collected Permian fossil insects from the Wellington shales near Elmo, Kansas with Carl O. Dunbar and his party from Yale.

1922. The Beamer and Paul B. Lawson families collected Cicadellidae in the Ozarks.

1924. Collected with Paul B. Lawson in western Kansas and eastern Colorado on a trip to the Pingree Park, Colorado conference.

1926. R. H. and L. D. Beamer made another collecting trip through western Kansas and eastern Colorado en route to a Pingree Park Conference.

1930. R. H. Beamer and Paul Oman made a spring collecting trip to Iowa and Illinois for *Erythroneura*.

1932. R. H. Beamer, P. A. Readio and Lyle Stevenson made a spring collecting trip to Arkansas for *Erythroneura*.

1932. R. H. and L. D. Beamer spent Christmas vacation on a collecting trip to New Orleans to attend A.A.A.S. meetings.

1947. R. H. and L. D. Beamer made a trip in March to Florida to collect Fulgoridae and try for *Ranatra* on the Keys.

1948. R. H. and L. D. Beamer pulled a trailer to Tucson, Arizona in April and May. Collected on the way and brought back the Torre-Bueno Collection of Hemiptera that had been purchased by the University.

1949. R. H. and L. D. Beamer spent Christmas vacation on a collecting trip to Vera Cruz, Acapulco and Mexico City where they were joined by J. G. Shaw.

1950-51. R. H. and L. D. Beamer collected in December and January in Florida for Fulgoridae.

1950. Easter vacation trip, R. H. and L. D. Beamer, C. D. and Mary Michener went to Texas for spring time insects.

1951. Easter vacation trip, R. H. and L. D. Beamer, C. D. Michener, Richard Fredrickson, Jerry and Barbara Rozen, and Bill Stephen to Texas.

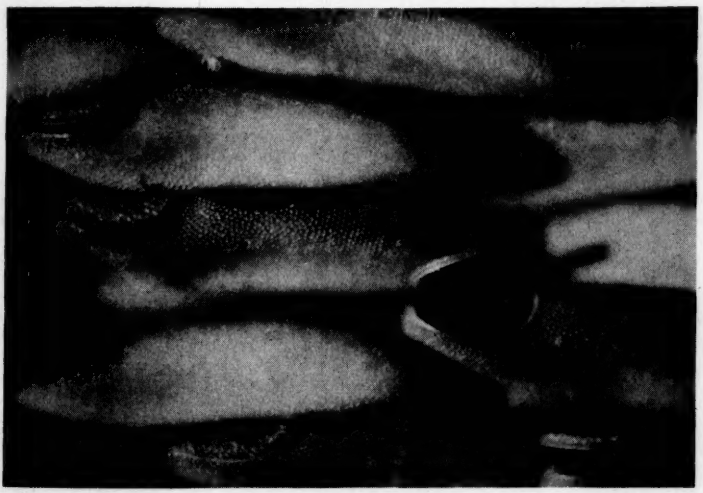
1952. Easter vacation trip, R. H. and L. D. Beamer and C. D. Michener to Texas.

CONCERNING A RABBIT CUTEREBRID, THE LARVAE OF WHICH MAY PENETRATE THE HUMAN SKIN (Diptera, Cuterebridae)[1]

LAWRENCE R. PENNER

Beamer and Penner (1942) reported successful rabbit exposures to first stage larvae hatched from eggs of a large, white sided, female cuterebrid collected in a pasture near Lawrence, Kansas, July 10, 1942. Larvae were also allowed to penetrate the human skin. A full account of this study has not appeared in the literature because accurate identification of the fly was prevented by the premature disappearance of the female and the failure of any of her eggs to develop to maturity. While it was my opinion that the fly was probably *Cuterebra buccata* (Fabricius) and I think Doctor Beamer concurred, we continued in our attempts to obtain further verification to corroborate our earlier findings. In this we were unsuccessful. However, it no longer seems valid to let the information lie idle so an account of some of our observations with illustrations from our materials is offered at this time. It is my sincere belief that Doctor Beamer would have wanted this information published so it seems particularly fitting to make it available for this memorial issue.

A gravid female *Cuterebra* was captured in a pasture on the Al Smith farm near Lawrence, Kansas, and brought alive by Doctor Beamer to the



Enlargement to show characteristic eggs.

[1] Contribution from the Department of Entomology, University of Kansas, and Department of Zoology and Entomology, University of Connecticut.

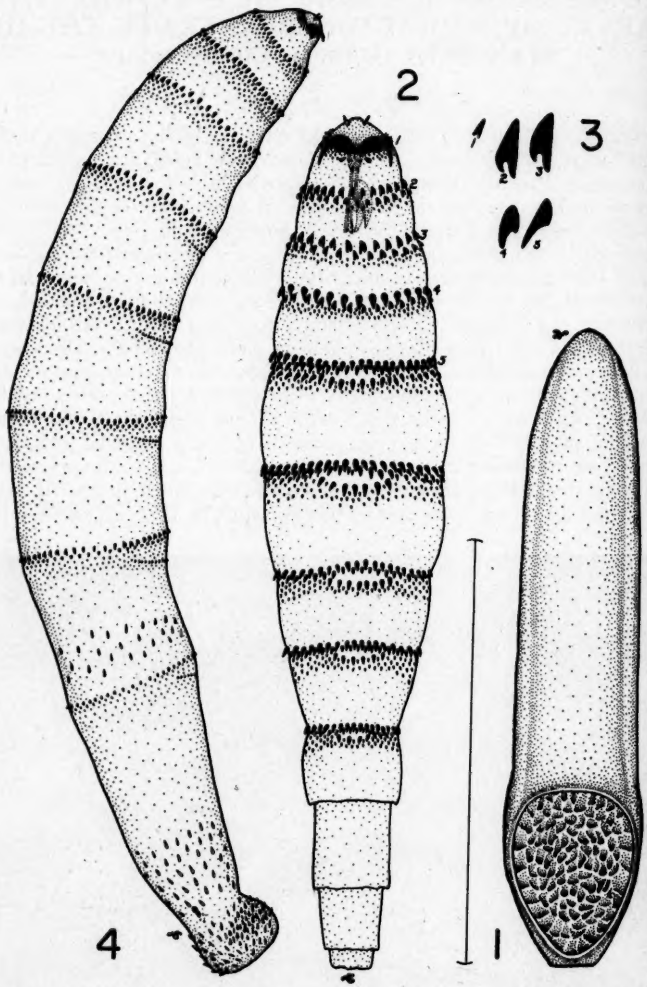


PLATE 1

Fig. 1. Egg of rabbit *Cuterebra*. Line to left of figure shows relative length of larva which emerged from egg. Fig. 2. First stage larva showing characteristic spination. Fig. 3. Enlargement of characteristic spines shown in numerical position in Figure 2. Fig. 4. Second stage larva from experimental rabbit six days after exposure to first stage larvae.

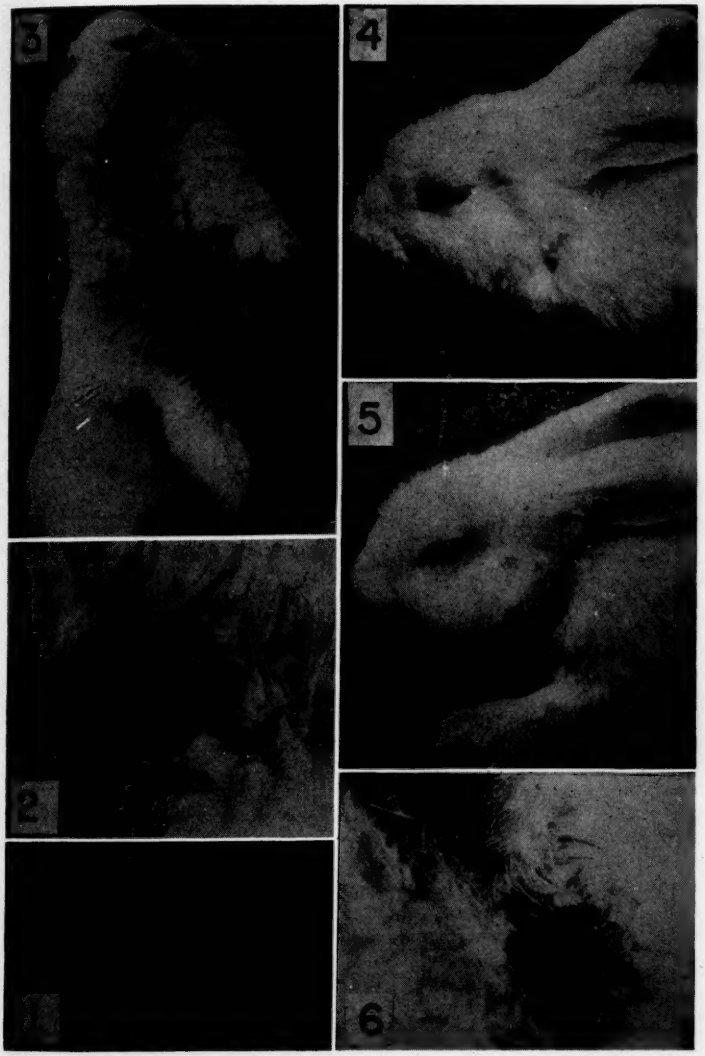
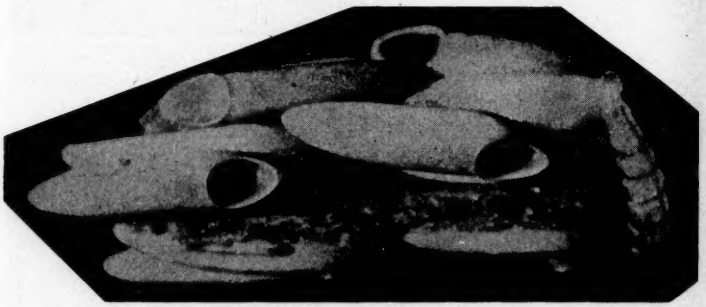


PLATE II

Fig. 1, Edema of human skin produced by first stage *Cuterebra* larva immediately after penetration and complete entry in 18 minutes. Fig. 2, Relatively clean grub hole showing posterior of third instar larva 25 days after exposure to first stage larvae. Fig. 3, Experimental rabbit 25 days after exposure showing third stage larvae. Fig. 4, Experimental rabbit 11 days after exposure showing bloody fur. Fig. 5, Same rabbit 15 days after exposure showing increased discharge. Fig. 6, Sero-purulent discharge from warble sore in experimental rabbit 25 days after exposure.

Snow Entomological Museum on July 10, 1942, where it was placed in a small laboratory cage. The female began to lay eggs in rows up to three-quarters of an inch long, depositing them on the sides of the cage, and on wild lettuce leaves and stems. Four juvenile pack rats (*Neotoma floridana osagensis* Blair) were then placed in her cage to determine whether their fur would offer suitable material for deposition of the eggs. The fly disappeared, the assumption being that she was eaten by the rats, and no eggs were found on the young rats! Doctor Beamer's comment regarding the loss was that "one's hindsight is always better than his foresight!" On July 14, larvae began hatching about 8 a.m. and continued hatching for several hours. Four larvae each were placed on two guinea pigs, one *Peromyscus leucopus*, four white rats, and the four juvenile pack rats. Eight larvae were placed on the fur and in the ears of two half grown white laboratory rabbits and



Eggs and one first stage larva hatched on fourth day after oviposition.

twenty-two larvae were placed on a third similar rabbit, ten of them on the inner side of the right ear near the tip, eight on the fur, and two in each nostril. No skin entry was observed and it is thought not unlikely that nostril entry was responsible for the successful rabbit infestations. Penner and Pocius (1956) have since reported nostril entry as highly successful for a rodent *Cuterebra* on which they have been working in Connecticut. This of course does not necessarily preclude other types of entry.

Three of the larvae were allowed to penetrate my skin. Complete entry of one larva took 18 minutes from time of first attachment. This was at the inside skin crease between the fore and upper left arm. A small white scar still persists where penetration and immediate surgical removal of the disappearing larva occurred. There was no intent to determine possible further development in man. Two other larvae were two thirds in when removed at 18 and 25 minutes, both in forearm creases. The three larvae allowed to penetrate my skin all produced a stinging sensation, one as early as nine minutes and another as late as 17 minutes after application and attachment. Edema following wheal formation and reddening resulted from their penetration. The edema subsided rapidly but the area remained somewhat inflamed and red up to two weeks following penetration.

The domestic rabbit receiving twenty-two larvae died on July 20. The postmortem revealed two second instar larvae, one under each foreleg in the connective tissue between the skin and underlying muscle tissue. One had made an opening in the skin to the exterior, whereas no similar opening could be found for the other larva.

Bloody fur on the other two laboratory rabbits was noted July 25, and five and four grubs were observed in sero-purulent sores. By August 13, three and one of these were mature and apparently ready to drop out. All but one disappeared and were apparently eaten by the rabbits. The last one dropped out on August 14, just 30 days after original exposure and was removed to a separate container for pupation. Emergence did not occur. None of the other experimental animals developed warbles. Some of the first instar larvae not used for exposures were kept alive from July 14 to August 5, when all were considered dead.

ACKNOWLEDGMENTS

Appreciation is expressed to Miss Mary Larson of the Department of Zoology, University of Kansas, for making available the laboratory animals, to Mr. Orin Bingham for photographic aid, and to Miss Addie Egbert for making the careful drawings.

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Penner, Lawrence R. and Felix P. Pocius. 1956. Nostril Entry as the Mode of Infection by the First Stage Larvae of a Rodent *Cuterebra*. Suppl. J. Parasitol., 42:42.

BEAMERELLA AND *KAAIA*, TWO NEW GENERA OF CHIGGERS FROM SOUTH AMERICA (Acarina, Trombiculidae)

JAMES M. BRENNAN[1]

Two new monotypic genera of the subfamily *Trombiculinae* were among numerous lots of chiggers submitted for identification by Dr. Thomas H. G. Aitken, Trinidad Regional Virus Laboratory, and by Dr. Carl B. Koford, Canal Zone Biological Area. These and the new species are described below.

Beamerella, new genus

Trombiculid larvae of the subfamily *Trombiculinae*. Trombicula-like in form and appearance. Cheliceral blades with strongly serrate distal ex-

[1] U. S. Department of Health, Education, and Welfare, Public Health Service, National Institutes of Health, National Institute of Allergy and Infectious Diseases, Rocky Mountain Laboratory, Hamilton, Montana.

pasion. Scutum more nearly verrucose than punctate. Sensillae flagelliform. Palpal tarsus with six branched setae, a subterminala and a tarsala.

Type species: Beamerella acutascuta, n. sp.

On the occasion of this memorial and tribute to Dr. Raymond H. Beamer, it is with pride and deepest sincerity that I dedicate this genus to the memory of my teacher and friend.

Beamerella acutascuta n. sp.
(Fig. 1)

Type data: Holotype, RML No. 34019, off bat, *Chilonycteris r. rubiginosa,* Tamana Hill Cave, Trinidad, British West Indies, 12 June 1956; 2 paratypes, RML No. 34020, same data as holotype; 2 paratypes, RML No. 33782, off bat, *Carollia p. perspicillata,* Melajo Forest, Sangre Grande, Trinidad, 9 March 1956.

Holotype and a paratype in the Rocky Mountain Laboratory. A paratype each in the United States National Museum, the British Museum (Natural History), and Muséum National d'Histoire Naturelle, Paris.

Diagnosis: Scutum more or less verrucose, posterior margin with acute median tip. Distal expansion of cheliceral blade hood-like, edged with about twenty distinct teeth.

Body: Broad ellipsoidal. Length and width of holotype, partly engorged, 425 by 329 microns. Eyes prominent, 2/2, the anterior larger, in a plate. Anus between fourth and fifth rows of ventral setae.

Gnathosoma: Cheliceral bases, femoral and genual plates, capitular sternum, punctate. Cheliceral blades with a distal hood-like expansion edged with at least twenty teeth which increase in size from tips; in addition, a single, larger ventral tooth proximal to hood. Palpal setal formula B/B/NNN. Palpal tibial claw trifurcate. Galeal seta nude.

Scutum: Wider than long, anterior margin sinuous, posterior margin broadly rounded, but with an acute median tip. Heavily verrucose rather than punctate. Sensillae relatively short with strong branches on apical two thirds. Scutal setae thick, with strong barbs, anteromedian posterior to anterolaterals. Scutal measurements of holotype: AW-70, PW-87, SB-22, ASB-33, PSB-25, AP-33, AM-31, AL-39, PL-39, S-40.

Legs: All segments punctate. *Specialized setae:* Leg I—3 genualae, microgenuala; 2 tibialae, microtibiala; very long tarsala, microtarsala distal to it, subterminala, parasubterminala, pretarsala. Leg II—genuala; 2 tibialae; tarsala much shorter than tarsala I, microtarsala proximal to it, pretarsala. Leg III—genuala; tibiala. *Branched setae:* Moderate number of semi-erect branches. Leg I—coxa 1, trochanter 1, basifemur 1, telofemur 5, genu 4, tibia 8, tarsus 16. Leg II—coxa 1, trochanter 1, basifemur 2, telofemur 4, genu 3, tibia 6, tarsus 14. Leg III—coxa 1, trochanter 1, basifemur 2, telofemur 3, genu 3, tibia 6, tarsus 12. All tarsi with a pair of claws and slender empodium.

Body setae: Dorsal setae similar to scutal setae, 22 to 36 microns long, decreasing in length posteriorly. Dorsal formula 2-6-6-6-6-4-2-2. Ventral setae 2-2 (sternals) plus about 44, most of those posterior to the anus similar to those anterior to the anus.

Kaaia, new genus

Trombiculid larvae of the subfamily *Trombiculinae*. Suggestive of *Heaslipia*. Seven scutal setae. Sensillae flagelliform. Palpal tibial claw simple. Palpal tarsus with six branched setae, a subterminala, and a tarsala.

Type species: Kaaia peruensis, n. sp.

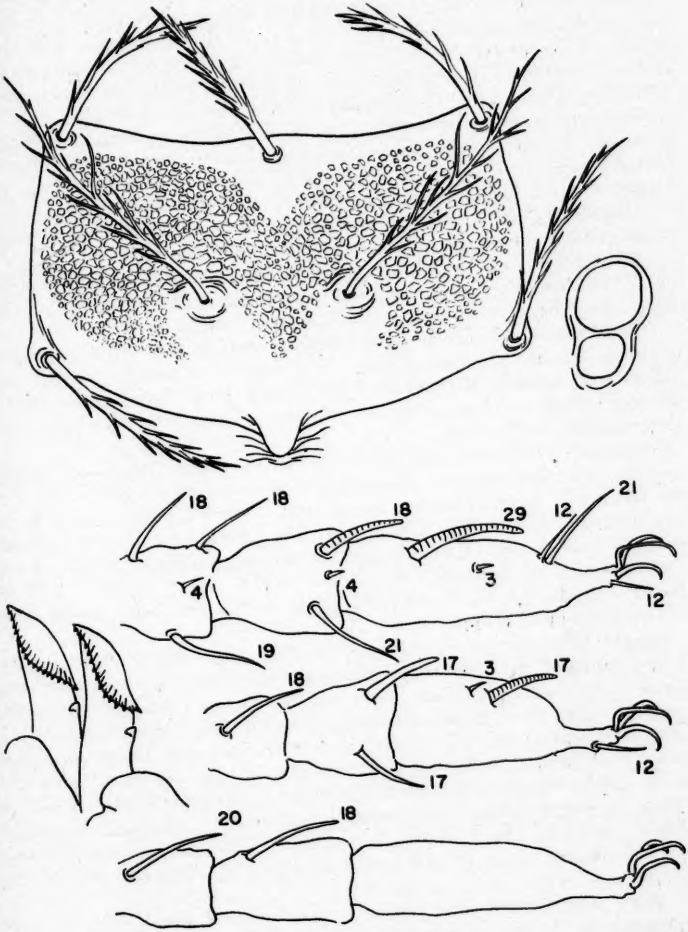

Fig. 1. *Beamerella acutascuta* n.g., n.sp. Scutum, eyes, specialized leg setae showing lengths in microns, and cheliceral blades.

Kaaia is affectionately named for Miss Kaa Byington, daughter of Dr. LeGrand Byington, Medical Director, U. S. Public Health Service, retired.

Kaaia peruensis, n. sp.
(Fig. 2)

Type data: Holotype and 12 paratypes, RML No. 31558, off *Punomys lemminus,* 8 mi. SSW Limbani, 15000 feet, Puno, Peru, 31 August 1951; 1 paratype, RML No. 31552, same host and locality, 14 June 1951; 10 paratypes, RML No. 31564, same data, 24 June 1951; 3 paratypes, RML No. 31556, off *Neotomys ebriosus,* same locality, 25 June 1951; 10 paratypes, RML No. 31546, off *Phyllotis osilae,* Heda, Pairumani, 24 mi. S. Ilave, 13000 feet, Puno, Peru, 15 April 1951. These hosts are rodents.

Holotype and some paratypes in the Rocky Mountain Laboratory. Other paratypes in the United States National Museum, the British Museum (Natural History), Muséum National d'Histoire Naturelle, Paris, the Museum of the Belgian Congo, and the South Australian Museum.

Diagnosis: Differs from species of *Heaslipia* in having a single-pronged palpal claw, 2 genualae I, and in lacking a mastitarsala III.

Body: Ellipsoidal. Length and width of holotype, slightly engorged, 402 by 272 microns. Eyes large, 2/2, in a plate, anterior and posterior eyes subequal. Anus between third and fourth rows of ventral setae.

Gnathosoma: Cheliceral bases, femoral and genual plates, capitular sternum, heavily punctate. Cheliceral blades with small tricuspid cap. Palpal setal formula B/B/NNB. Claw simple, long. Palpal tarsus with 6 branched setae, a subterminala and a tarsala. Galeal seta branched, sometimes forked, rarely nude.

Scutum: Wider than long, posterior margin shallow convex or broadly angulate. Densely punctate. Sensillae barbed, apparently fragile, since they are lacking in most specimens. Scutal setae thick, with short coarse barbs, thickness of PL and PPL>AL>AM. AM posterior to AL. Occasionally a scutal seta or two in addition to the normal complement of 7. Scutal measurements of holotype: AW-101, PW-121, SB-55, ASB-38, PSB-29, AP-26, AM-62, AL-50, PL-64, PPL-67, S-—. The holotype has an extra PL on one side of scutum.

Legs: All segments conspicuously punctate. *Specialized setae:* Leg I—2 long genualae, microgenuala; 2 tibialae, microtibiala; tarsala, microtarsala distal to it, parasubterminala (branched in one specimen), subterminala, pretarsala. Leg II—Genuala; 2 tibialae; tarsala a trifle longer than tarsala I, microtarsala proximal to it, pretarsala. Leg III—genuala; tibiala. *Branched setae:* Two kinds, usually the shorter ones pectinate, the longer ones plumose. Leg I—coxa 1, trochanter 1, basifemur 1, telofemur 5, genu 4, tibia 8, tarsus 14. Leg II—coxa 1, trochanter 1, basifemur 2, telofemur 4, genu 3, tibia 6, tarsus 12. Leg III—coxa 1, trochanter 1, basifemur 2, telofemur 3, genu 3, tibia 6, tarsus 11. All tarsi with a pair of claws and slender empodium.

Body setae: Dorsal setae similar to posterolateral scutal setae, 55 to 70 microns long, decreasing in length medially and posteriorly. At least 2 pairs of humerals plus 38 to 46 setae in irregular rows. Ventral setae 2-2 (sternals) + 16, the 4 setae in 2 rows behind the anus similar to dorsal setae.

SUMMARY

Two new South American genera and species of chiggers, *Beamerella acutascuta* off Trinidadian bats, and *Kaaia peruensis* from rodents of the Peruvian highlands, are described. Type host of the former, *Chilonycteris r. rubiginosa,* of the latter, *Punomys lemminus.*

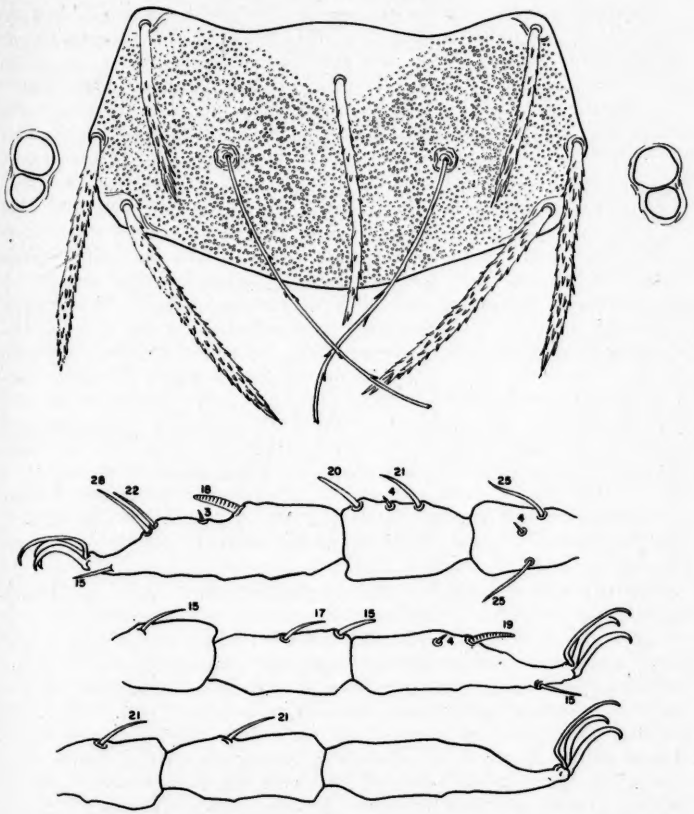

Fig. 2. *Kaaia peruensis* n.g., n.sp. Scutum, eyes, and specialized leg setae showing lengths in microns.

A REVIEW OF THE GENUS *NEOSOPHIRA* HENDEL (Diptera, Tephritidae)[1]

D. ELMO HARDY
Hawaii Agricultural Experiment Station, University of Hawaii, Honolulu

The original reference for the genus *Neosophira* has been cited as Hendel, 1914, Abhandl. Zoo.-Bot. Ges. Wien 8(1):138. According to Neave (Nomenclator Zoologicus) this was published in June, 1914. At this time Hendel treated *Neosophira* as a "n. gen." of Otitidae under the subfamily Platystominae. He later changed his mind and in his "Die Gattungen der Bohrfliegen" (1914, Wien. Ent. Zeit. 33:73) placed it in its correct position under the fruit flies; the latter paper (even though obviously written later) was published April 30, 1914. Hendel also published "*Neosophira* nov. gen." in his 1914, Genera Insectorum 157:76. I cannot learn which month this was published but presume the Wien. Ent. Zeit. reference to be the earliest.

Neosophira belongs in the subfamily Dacinae, tribe Adramini and is differentiated from related genera by having the last section of vein M_{1+2} bent upward so that the apex of cell R_5 is narrowed (fig. 3a). The femora are devoid of ventral bristles and the front tibia lacks an apical spur. The following bristles are lacking: pteropleural, sternopleural, humeral, dorsocentral, presutural, ocellar, postvertical, and outer vertical. The front contains but one pair of orbital bristles; these are superior fronto-orbitals and they are situated at the upper three fifths of the front. The mesonotum and scutellum are densely covered with erect dark-colored setae and the scutellum has four strong marginal bristles. The cubital cell is developed into a sharp-pointed lobe at lower apex and the wings are predominantly brown, streaked with yellow fumose markings (figs. 1a, 2 and 3a). The arista is long plumose. The genae of the males are lobate at least in *N. arcuosa* (Walker).

The genus *Colobostroter* Enderlein (based upon *C. pulchralis* Enderlein) appears related to *Neosophira* in spite of the fact that it has been treated under the Trypetinae. I have studied the female specimen of *C. pulchralis* and it lacks pteropleural, sternopleural, humeral, presutural, ocellar, postvertical, and outer vertical bristles. Also there are apparently no prescutellar or dorsocentral bristles (I cannot be absolutely sure of this since the nadeln penetrates the thorax of the specimen at this point). The apical portion of vein M_{1+2} curves upward narrowing the apex of cell R_5 as in *Neosophira* and also the subcostal vein does not bend upward quite so sharply, slanting more gradually into the costa than is typical for Tephritidae. The only characters which I see for differentiating *Colobostroter* from *Neosophira* are that an inferior fronto-orbital bristle is developed, the superior fronto-orbitals are rather weak and vein R_{2+3} has an appendix below, near the outer one third of the vein. The dorsum of the thorax is thickly covered with erect dark-colored hairs as in *Neosophira*.

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[1] Published with the approval of the Director of the Hawaii Agricultural Experiment Station as Technical Paper No. 411.

To date but three species are recognized in *Neosophira;* they are known only from Indonesia (Celebes, Moluccas and Amboina). The present study is based upon specimens in the British Museum collection.

Type of the genus: *Sophira distorta* Walker.

Key to known species of *Neosophira* Hendel

1. Face with a large black spot in the middle. Abdomen entirely rufous or with brown to black discolorations in the median portions of terga two to four in *distorta* males. Cell R_5 with hyaline markings beyond the level of m crossvein 2
   Face all yellow; abdomen with a yellow longitudinal vitta down the middle, otherwise black. Cell R_5 all dark brown beyond m crossvein (fig. 2) (Moluccas) ..... *clavigera* n. sp.
2. Vein R_2 very elongate, ending in costa well beyond the level of upper edge of m crossvein. Apex of cell R_5 scarcely as long as r-m crossvein. Mesonotum entirely rufous. Genae of males not lobate. Wings as in fig. 3a. (Celebes) ..... *distorta* (Walker)
   Vein R_1 ending in costa well before the level of the m crossvein. Apex of cell R_5 broader than length of the r-m. Mesonotum with a large black spot behind each humerus. Genae of male produced, lobe-like (fig. 1b). Wings as in fig. 1a. (Celebes, Amboina) ..... *arcuosa* (Walker)

Neosophira arcuosa (Walker), n. comb.
(Figs. 1a, 1b)

Enicoptera arcuosa Walker, 1860, Jour. Proc. Linn. Soc. London 4:156.
Neosophira ferruginea Hendel, 1914, Abh. K. K. Zoo.-Bot. Ges. Wien 8(1):138. New synonym based upon a comparison of Walker's type with Hendel's description and figure (see Hendel, 1914, Gen. Ins. 157, pl. 3, fig. 64).

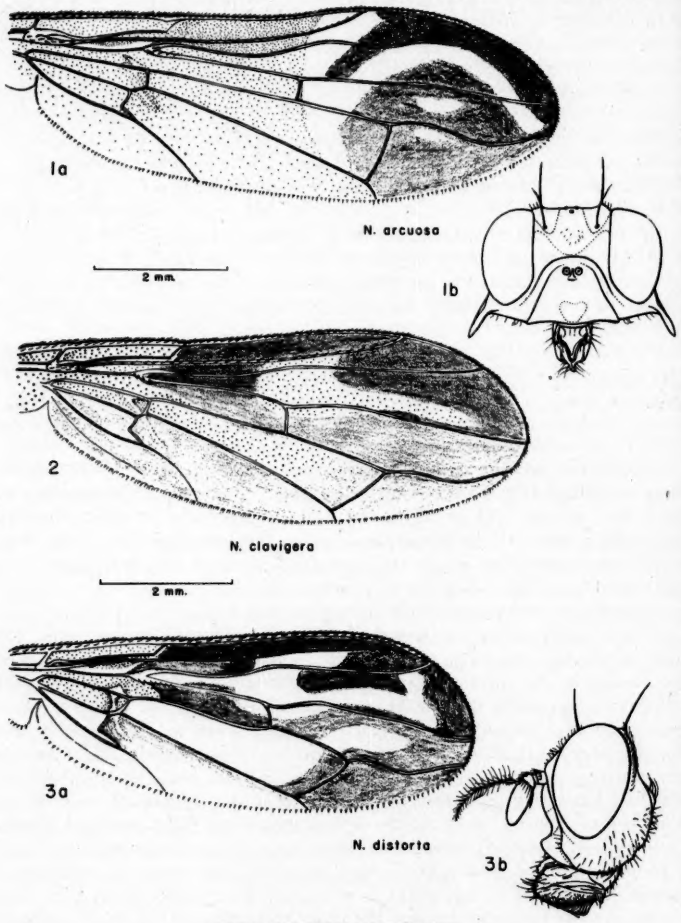
Neosophira arcuosa is a well defined species easily characterized by the wing markings (fig. 1a), as well as by other details. The development of the lower occiput and genae in the male is especially peculiar; in some specimens a slender lobe is developed from the lower portion of the head which may be equal or longer than the third antennal segment (fig. 1b); in other specimens just a slight lobe is developed.

Descriptive notes based upon the cotype series.

Head: In direct frontal view the head is distinctly wider than long. The front is broader than long; the superior fronto-orbital bristles are situated at the middle of the front and are almost as strong as the verticals. A black stripe extends down the median portion of the front to just above the lunule, an arm extends out on each side and runs obliquely to the eye margin just in front of the superior fronto-orbital bristles. The face is moderately concave on the lower portion and the epistoma is projected. The face has a large oval spot across the median portion at the lower third; this does not extend as far as the antennal furrows. The antennae are entirely yellow; the third segment is about three times longer than wide and is rounded at apex. The arista is long plumose. The occiput is strongly inflated below, at its widest point it is approximately two thirds the width of one eye. As mentioned above the male genae are lobate; refer to fig. 1b for the extreme development of the genae in the male specimens at hand.

Thorax: Entirely rufous except for a large black spot behind each humerus

and for a narrow brown to black longitudinal vitta extending from just behind the suture to approximately opposite the postalar bristles, in line with the sides of the scutellum. Each mesopleuron has a narrow vertical, brown stripe near the hind margin. *Wings:* Venation very near that of *distorta*. The apical cell (cell R_5) is not so strongly narrowed; however, at the apex it is greater in width than the length of the r-m crossvein. The cubital cell has a comparatively short pointed lobe at apex; it is less than



EXPLANATION OF FIGURES

1. *Neosophira arcuosa* (Walker). a. wing; b. head, front view. 2. *N. clavigera* n. sp. wing. 3. *N. distorta* (Walker). a. wing; b. head, lateral view.

the length of the vertical section of vein Cu_1 (fig. 1a). *Abdomen:* Entirely rufous in both sexes. The ovipositor has been broken off the female specimen at hand.

Length: Body and wings, 11.0-12.0 mm.

Type locality: Celebes, Near Makassar.

Cotype series, three males and one female, in the British Museum (Natural History).

I have studied Walker's series.

Neosophira clavigera n. sp.
(Fig. 2)

A female specimen in the British Museum collection had been labeled *"clavigera"* by Walker. It was in one of the Otitidae trays marked "genus?" and was directly beneath the specimens of *Enicoptera arcuosa* Walker; Walker probably considered it in this genus. I find no reference to Walker's *clavigera* and it was probably a cabinet name. I am describing it as a new species of *Neosophira.*

N. clavigera differs from the other known species of *Neosophira* by having the face all yellow and the abdomen black with a yellow longitudinal vitta down the middle; also the wing markings are distinctive (fig. 2). The chaetotaxy of the head and thorax is identical with that of the type of the genus.

Head: The face is entirely yellow and in profile is predominantly convex, with a rather shallow concavity on the lower portion. The epistomal margin is not distinctly produced. The front is about as wide as long, measured from the lower ocellus to the lunule, with a broad black mark extending down the median portion from the vertex to about the lower fourth; the remainder of the front is yellow. Only the first two segments and a portion of the third antennal segment remain on the specimen at hand; these are all yellow. The arista is long plumose. The genae are not so well developed as in female *distorta;* they are slightly less than one fourth as high as the eye. The lower occiput is puffed and at its broadest point is half the width of the eye. *Thorax:* Predominantly rufous, with a brown spot immediately in front of each humerus and a moderately large black spot immediately behind. The inner hind margin of the humerus is brown. The mesopleura each have a brown vertical stripe covering approximately the hind third of the sclerite. A brown to black spot is present on the upper median portion of each sternopleuron. The mesonotum has a pair of large black spots just before the scutellum, extending anteriorly to a level with the anterior supraalar bristles; these appear to be narrowly joined on the posterior edge of the scutellum (this region is obscured by the nadeln and I cannot be sure). Scutellum entirely yellow. *Legs:* Yellow. *Wings:* As in fig. 2. Vein R_{4+5} has just a few setae near its base. Vein R_1 enters the costa at a level just slightly beyond the upper portion of the m crossvein. Vein R_{2+3} has a slight upward dip in the median portion. The r-m crossvein is situated near the apical two thirds of cell 1st M_2. The last section of vein M_{1+2} is bent upward at the apical portion. The apex of cell R_5 is approximately equal to the length of the r-m crossvein. The cubital cell has a slightly shorter apical lobe than in *distorta;* it is approximately equal to the

vertical portion of vein Cu_1. *Abdomen:* The terga are broadly black on the sides with a longitudinal yellow vitta extending the entire length down the median portion. The venter is entirely yellow. The ovipositor is yellow. The basal segment *in situ* is slightly longer than segments four and five.

Length: Body, 11:25 mm.; wings, 11.7 mm.
Holotype female, Moluccas, Sula Island.
Type in the British Museum (Natural History).

Neosophira distorta (Walker)
(Figs. 3a, 3b)

Sophira distorta Walker, 1857, Trans. Ent. Soc. London n. s. 4:230.
Enicoptera pictipennis Walker, 1860, Jour. Proc. Linn. Soc. London 4:155.

This species is readily differentiated from other *Neosophira* by the wing venation and coloration as pointed out in the key above and as in fig. 3a. The following descriptive notes are based upon the type.

A large, predominantly yellow to rufous species with black markings only on the front and face. *Head:* The front is as broad as long and has a broad, black stripe extending down the middle from the vertex to the lunule. One pair of moderately small, superior fronto-orbital bristles are developed; these are about equal in size to the small bristle on the hind portion of the mesopleuron. The face is slightly convex on the upper portion and is rather deeply concave at about the lower third, with the epistoma strongly projecting (fig. 3b). The median portion of the face (the area of the concavity) has a transverse black mark extending into the sides of the antennal furrows. Only one pair of bristles is present on the back of the head; these are the inner verticals; the outer verticals and postverticals are lacking. There are no ocellar bristles on the specimens at hand. The upper occiput, behind the eyes, has a row of rather fine, brownish hairs; no distinct bristles are developed in this occipital row. There are no genal bristles developed and no bristles are present along the sides of the oral margin. The genae are approximately one third the height of the eye. The first antennal segment is yellow, the second is yellow except for the black dorsal surface. The third segment is yellow basally and brown to black toward the apical portion; it is about two and one half to nearly three times longer than wide and is rounded at the apex. The arista is long, plumose; the longest hairs are considerably greater than the width of the third segment. *Thorax:* With no prescutellar, dorsocentral, humeral, presutural, sternopleural or pteropleural bristles. The pleurotergite is bare. The mesonotum and scutellum are densely covered with fine, suberect, brown hairs. The scutellum has four marginal bristles. *Legs:* The hind two pairs of femora are long and slender; they are approximately equal in length to the combined lengths of the first four abdominal segments. The legs are completely unarmed, with no bristles, except at the apices of the middle tibiae. Each middle tibia has one long, and one short apical spur. *Wings:* With very characteristic venation (fig. 3a). The subcostal vein slopes gently into the costa. Vein R_1 is very elongate and reaches the costa at a point considerably beyond a level with the m crossvein. Vein R_{2+3} is undulate; it has one upward curve at about the middle. The last section of vein M_{1+2} is rather sharply curved upward toward the apex, greatly narrowing the apical cell. The r-m crossvein

is situated near the apical one fourth to two thirds of cell 1st M_2. The cubital cell has a narrow, sharply pointed lobe at apex; this is longer than the vertical section of vein Cu_1 (fig. 3a). Vein R_1 is setulose from the humeral crossvein approximately to its tip. The other veins are bare except for about eight to ten setae along the basal portion of vein R_{4+5}. The wing markings are as in the fig. 3a. *Abdomen:* Entirely rufous in female and with terga two to four discolored with black in the median portions in the male. The abdomen is densely covered with suberect fine yellow to brownish pile. The ovipositor is yellow, the basal segment (in the specimen at hand) is almost equal to the length of terga three to five.

Length: Body of both sexes 14.4 mm.; wings of male, 14.8 mm.; wings of female, 15.7 mm.

Type locality: Celebes.

Type in the British Museum (Natural History).

I have studied the type female, which is in rather poor condition; the head has been partially eaten away. Another female from Menado, Celebes, is also in the British Museum collection.

NEW RECORDS, SYNONYMY, AND SPECIES OF TEXAS *CULICOIDES* (Diptera, Heleidae)

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The primary intent of this paper is the clarification of the taxonomic status of a few of the many North American species of *Culicoides* whose position and relationship to other species are uncertain. The formulation of species concepts depends largely on the recognition of the variation between populations of the same species. The proper characterization of any species requires the examination of specimens from geographically separated populations and from habitats having maximum ecological differences.

Most of the new Texas records reported here were obtained in the Aransas National Wildlife Refuge, which is located along the Gulf of Mexico in southern Texas. One species new to Texas was obtained from the Big Bend National Park, situated in southwestern Texas along the Rio Grande River. Collections made at the Aransas Refuge light traps in the spring of 1956 are given in Table I. Because of their unusual character all species collected are included.

These data indicate that one or two light-trap collections per week are insufficient to show accurately the seasonal fluctuations in population density and the species content of an area. For this purpose a light trap should be run every day; otherwise peaks of short duration may be missed and the rarer species may be completely overlooked. The peak catches in Table I could not be correlated with minimum, maximum, or minimum-maximum

changes in daily temperatures. The rainfall during the collection period was insignificant, and apparently had no bearing on the occurrence of maximum or minimum catches. Peak collections possibly coincide with maximum emergences from the breeding areas, as the weather conditions during this period were relatively stable. However, less significant changes than shown by normally recorded weather data probably play an important role in determining adult activity.

Light traps run occasionally are of value in determining the approximate species content of an area and their relative abundance, in sampling geographic areas for variation studies, and in experiments where the catches are related to studies of the breeding sites within the range of the light trap. In variation studies it is almost essential to correlate studies of the breeding sites and light-trap collections. A reared sample indicates the variation within that population at that particular time. The common collection of variants from these reared specimens in a light trap operated at the same time and in the same area indicates the presence of unsampled niches. In addition to sampling possibly more than one ecologically distinct population, a light trap also indicates variations due to longer range seasonal changes. Correlation of the two procedures is necessary to indicate the levels of attractiveness to light for different species.

In the descriptions and discussions that follow, the terminology of the wing follows that of Tillyard. Cell Cu_1 and veins Cu_1 and Cu_2 of some authors are called cell M_4 and veins M_{3+4} and Cu_1, respectively.

The authors are indebted to the officials of the U.S. Department of Interior, Fish and Wildlife Service and the National Park Service, respectively, for granting permission to collect in the Aransas National Wildlife Refuge and Big Bend National Park. The senior author is especially grateful to the personnel of the Aransas Refuge for operating the light trap at their headquarters from May 28 through June 12. The authors also thank John A. Quist for his assistance in comparing the genitalia of Texas material of *C. stonei* with the holotype male deposited at Colorado A&M College.

Culicoides oklahomensis Khalaf, new status

Culicoides villosipennis oklahomensis Khalaf 1952. Ann. Amer. Ent. Soc. 45:335; Khalaf 1954, Ann. Amer. Ent. Soc. 47:37; Fox 1955, Jour. Agri. Univ. Puerto Rico 39:223.
Culicoides arboricola of Wirth and Bottimer 1956, in part (misdetermination), Mosquito News 16:261.

New status, records, and taxonomy.

New records: Mexico: Sonora, Agua Caliente, light trap, 25 VII 1956, Ryckman, Spencer, and Christenson, 2 ♀♀ and 2 ♂♂. Texas: Kerr County, light trap, 1956, R. H. Jones, 33 ♀♀ and 9 ♂♂: W. C. Schwethelm ranch, 1 ♀ and 1 ♂ (1 ♀ 17 VIII, 1 ♂ 5 IX); U. S. Dept. Agri. Expt. Sta., 32 ♀♀ and 8 ♂♂ (1 ♀ 30 VIII, 7 ♀♀ 1 IX, 3 ♀♀ 2 IX, 1 ♀ 3 IX, 4 ♀♀ and 4 ♂♂ 6 IX, 1 ♀ 7 IX, 4 ♀♀ 9 IX, 2 ♀♀ 10 IX, 2 ♀♀ and 1 ♂ 11 IX, 1 ♀ and 1 ♂ 12 IX, 1 ♀ and 2 ♂♂ 16 IX, 1 ♀ 19 IX, 1 ♀ 25 IX, 2 ♀♀ 28 IX, and 1 ♀ 9 X).

Previously recorded from: Oklahoma (type locality).

The examination of specimens thought to be *arboricola* R. & H. from Kerr County 1956 light-trap collections showed the presence of *oklahomen-*

TABLE I

TABLE I

Numbers of individuals of various species of *Culicoides* collected in light traps in the Aransas National Wildlife Refuge, 1956

		IV	V					VI											
Species	Sex	22	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	Total
arboricola	♀	10	....	....	....	1	6	4	3	....	....	1	....	1	5	3	5	1	4	44
R. & H.	♂	14	....	....	....	....	....	7	3	....	....	....	....	....	....	1	4	4	2	35
arubae	♀	15	1	5	5	22	74	34	10	3	1	35	2	9	99	35	7	4	26	387
Fox & Hoff.	♂	6	....	2	1	6	9	25	9	3	....	7	3	9	7	4	8	4	3	106
bermudensis	♀	2	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	6	8
Williams	♂	5	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	....	2	8
crepuscularis	♀	95	....	7	6	27	207	483	304	7	....	28	1	4	131	39	26	24	19	1407
Mall.	♂	18	....	....	....	6	39	135	55	3	2	6	1	....	9	7	16	9	6	312
	intersex	....	....	1	....	1	7	53	6	....	....	....	....	....	....	....	1	....	....	69
haematopotus	♀	....	....	....	....	....	4	74	22	....	....	2	....	....	11	7	5	2	6	133
Mall.	♂	1	....	....	....	....	....	18	8	....	....	....	....	....	....	1	8	....	5	41
hinmani	♀	2	....	....	....	....	....	6	3	....	....	....	....	....	1	....	2	....	....	14
Khalaf	♂	1	....	....	....	....	....	4	1	....	....	....	....	....	....	....	1	1	1	9
loughnani	♀	....	....	....	....	....	....	....	1	....	....	....	....	....	1	....	....	....	1	3
Edwards	♂	1	....	....	....	....	....	....	....	....	....	....	....	....	....	....	1	....	....	2
ousairani	♀	19	....	5	....	7	22	86	47	5	5	4	3	20	32	25	34	15	20	349
Khalaf	♂	25	1	1	1	2	11	68	33	4	....	5	3	13	21	8	39	6	18	259
stonei	♀	210	....	2	....	2	35	324	115	1	....	1	....	2	30	25	18	2	8	775
James	♂	83	....	....	....	....	12	126	25	....	....	1	....	1	28	4	10	1	5	296
variipennis	♀	15	....	....	1	1	12	6	3	1	1	....	....	....	4	3	....	1	3	66
australis Wirth & Jones	♂	17	....	1	....	....	5	3	....	1	....	....	....	....	4	1	1	....	....	40
Rare or undetermined species	♀	2[a]	....	....	....	....	1[c]	1[d]	1[e]	....	....	....	....	....	....	....	1[d]	....	2[e]	8
	♂	1[b]	....	....	....	....	....	....	3[e]	....	....	....	....	....	....	....	1[c]	1[e]	....	6
Totals		542	2	24	14	75	444	1470	658	29	10	91	13	59	384	163	188	75	137	4378
Tempertaure (°F.): Maximum (day trap set up)		71	88	88	88	88	89	89	94	89	88	88	89	89	89	89	95	88	91	
Minimum (day catch removed)		65	76	78	78	77	73	72	71	75	78	74	75	....	86	70	71	....	70	

[a] *biguttatus* (Coq.), [b] *neopulicaris* Wirth, [c] 2 undetermined species, [d] *nanus* R. & H., [e] *multipunctatus* Mall.

sis in addition to *arboricola*. This species is indistinguishable from *arboricola* on the basis of external characters. The males can readily be separated with slide-mounted material, as the genitalia of *oklahomensis* have lateral projections apically on the aedeagus as in *villosipennis* R. & H.

All the eight males of *oklahomensis* were collected in a light trap operated from September 6 to 28. Of the 30 females collected during this period, all apparently *arboricola*, 21 were mounted on slides and an effort was made to separate them into two groups on the basis of structural characters. Table II gives the data for this separation as determined by characters of the mouth parts, which were the only characters found to be of any value in separating these females into two distinct groups.

TABLE II

Separation of *Culicoides arboricola* R. & H. from *C. oklahomensis* Khalaf on the basis of characters of the female mouth parts, with a comparison of these characters for related species.

Species	Locality	Number of specimens dissected ♂	♀	Mandible (number of teeth)[a] Total	Per unit length	Ratio of height of head minus proboscis to proboscis[a]
oklahomensis	Mexico	2	2	13.3(13-14)/ 3	7 (7 - 7)/ 2	1.6(1.6-1.6)/ 2
	Texas, Kerr	8	13	12.4(11-14)/19	6.7(6.5- 7)/12	1.5(1.4-1.6)/13
arboricola	Texas, Kerr	8	8	16.4(15-18)/14	8.7(8 -10.5)/ 7	1.2(1.2-1.3)/ 8
	Texas, Aransas	20	9	15.7(14-18)/11	8.8(7.5-10)/ 7	1.2(1.1-1.3)/ 9
	Wisconsin	3	3	16 (16-16)/ 2	9.5(8.5-10.5)/ 3	1.2(1.2-1.2)/ 2
villosipennis	Wisconsin	....	7	13.4(13-14)/ 5	7 (7 - 7)/ 2	1.6(1.6-1.6)/ 3
guttipennis	Wisconsin	....	9	19 (19-19)/ 2	9.5(9 -10)/ 2	1.3(1.3-1.4)/ 7
pecosensis	Texas	....	6	17.1(15-20)/ 6	9.2(8.5-10)/ 8	1.4(1.3-1.4)/ 3
ousairani	Texas	....	7	14.2(13-15)/ 5	6.9(6.5- 7.5)/ 4	1.5(1.4-1.6)/ 7

[a] Average (range)/number of measurements.

Confirmation of this separation of the two species is indicated by the other localities as given in Table II. Collections from Mexico, Wisconsin, and the Aransas Refuge, Texas, consisted of only one of the species, as shown by the conformation of the male genitalia. After the Kerr County females had been separated into two distinct groups, females from these other areas were examined to substantiate this separation.

In comparison with *arboricola*, the female of *oklahomensis* has a shorter proboscis, with the mandibles having fewer and larger teeth. In both these species the light spot on the crossvein is large, extending anteriorly to the

costa and posteriorly broadly through vein M_{1+2}, and vein Cu_1 is bordered for at least part of its length by a distinct light spot; whereas in *villosipennis* and *ousairani* Khalaf the light spot on the crossvein is small, at most barely extending beyond vein M_{1+2} posteriorly, and vein Cu_1 lies in a dark area. In *guttipennis* (Coq.) and *pecosensis* Wirth the light spot on the crossvein is large as in *arboricola;* however, vein Cu_1 lies in a dark area (in some specimens there is a slight indication of a narrow light border). All these species except *ousairani* have similar mesonotal disc patterns of light markings on a dark background; antennal segments III-X with sensoria on segments III, V, VII, and IX (except for *pecosensis,* which has them on segments III-IX, with various sensoria frequently being absent); and the third palpal segment with a moderately deep sensorial pit. In contrast, *ousairani* has the anterior half of the mesonotal disc unicolorous dark brown (in alcoholic material the ground pattern of some specimens is similar to that of the other species), antennal segments III-X all with sensoria, and the third palpal segment with a very deep sensorial pit. All six of these species have the hind tibial comb armed with five spines.

The male genitalia of these species are similar except for *guttipennis,* in which they are distinctive. Four of these six species have been reared. The pupae of both *guttipennis* and *ousairani* possess distinctive characters, whereas *arboricola* and *villosipennis* are separated with difficulty on the basis of pupal characters. It is hoped that *oklahomensis* and *pecosensis* will be reared and that the characters of their pupae will be of assistance in clarifying the relationships among these latter four closely related species. The collection and examination of specimens from additional localities is essential to deciding their exact taxonomic status.

In the key to the females of the Nearctic species of the subgenera *Beltranmyia* and *Oecacta* (Fox, 1955), *ousairani* and *oklahomensis* are misplaced. The light spot on the crossvein in *ousairani* is small, at most barely extending past vein M_{1+2} posteriorly. In *oklahomensis* vein Cu_1 (Cu_2 of Fox) is bordered by a light spot. A revision of his couplets 14 and 15 is as follows:

a. Mesonotal pattern on anterior half unicolorous dark brown, antennal segments III-X with sensoria ..... *ousairani*
Mesonotal pattern on anterior half comprised of light markings on a dark background, antennal segments III-X with sensoria on segments III, V, VII, and IX (except in *pecosensis* which has them variously on III-IX ..... b

b. Light spot on crossvein small, at most barely extending past vein M_{1+2} posteriorly ..... *villosipennis*
Light spot on crossvein large, extending well beyond vein M_{1+2} posteriorly c

c. Vein Cu_1 lying in a dark area ..... d
Vein Cu_1 bordered by a distinct light spot for at least part of its length e

d. Wing with small light spots, the one in cell Cu_1 not attaining wing margin posteriorly ..... *guttipennis*
Wing with large light spots, the one in cell Cu_1 broadly attaining wing margin ..... *pecosensis*

e. Mandible with 11-14 teeth, the ratio of height of head minus proboscis over proboscis 1.4-1.6 ..... *oklahomensis*
Mandible with 14-18 teeth, the ratio of height of head minus proboscis over proboscis 1.1-1.3 ..... *arboricola*

Culicoides arubae Fox and Hoffman

Culicoides arubae Fox and Hoffman 1944, Puerto Rico Jour. Public Health & Trop. Med. 19:110.

New State record.

Aransas Co. light trap (see Table I). Cameron Co., Port Isabel area, State Highway 1792, reared from edge of salt-water pool, 31 I 1957, Jones, 2 ♀ ♀ and 4 ♂ ♂. Numerous reared specimens, Aransas National Wildlife Refuge, San Antonio Bay: edge of salt-water pools, 22 IV 1956, Wirth and Jones; edge of salt-water pools and overflow area of salt-water well, 27 V and 13 VIII 1956, Jones.

Previously recorded from: Aruba, Dutch West Indies (type locality); Venezuela, Barbosa (1947); Panama, Wirth and Blanton (in press).

The listing of the Venezuela record under the distribution of *C. variipennis* (Coq.) in Wirth (1952a, p. 181), "Barbosa (1947), Venezuela (sic, for *arubae* Fox and Hoffman)," is a miscitation. The Panama record is based on material in the U.S. National Museum and is listed here to complete the distribution records to date: from Aruba in the Dutch West Indies, to Venezuela, Panama, and the Gulf Coast of Texas.

Culicoides bermudensis Williams

Culicoides bermudensis Williams 1956, Jour. Parasitol. 42:298.

New State record.

Aransas Co. light trap (see Table I). Aransas Co. light trap No. 2, 27 V 1956, Jones, 1 ♀. Reared 17 ♀ ♀ and 23 ♂ ♂, Aransas National Wildlife Refuge, San Antonio Bay: edge of salt water pool, 22 IV 1956, Wirth and Jones, 2 ♂ ♂; edge of salt water pools and overflow area of salt water well, 27 V and 13 VIII 1956, Jones, 17 ♀ ♀ and 21 ♂ ♂.

Previously recorded from: Bermuda (type locality); Florida, Beck (1956).

Culicoides brookmani Wirth

Culicoides brookmani Wirth 1952a, Univ. Calif. Publ. Ent. 9:179.

New State record and new taxonomy.

Brewster Co., Big Bend National Park, Glen Springs, light trap, 7 IV 1956, Jones, 16 ♀ ♀ and 8 ♂ ♂. These specimens were collected along with tremendous numbers of *C. hieroglyphicus* Mall. Owing to the difficulty of separating alcoholic material of these two species, the analysis of light-trap collections from this area has only been started.

Previously recorded from: California (type locality).

Wirth in his original description states: "Aedeagus a pair of heavy boomerang-shaped sclerites, abruptly bent in middle, basal arms turned laterocephalad, apices far apart and slightly slenderer than base. Parameres fused in Y-shaped plate, paired basal arms widely spaced, with broad anterior arch, median posterior arm conical, with slightly truncated tip." This entire description and figure (page 177, a) apply to the aedeagus. The parameres are turned ventrad in most specimens and are therefore in-

distinct or visible only as a narrow band. Dissected material shows that the parameres are fused into a plate, with narrow, slightly incurved, more heavily sclerotized basal arms that join narrowly for the median third of their combined length; this median third with a short, broadly rounded caudomesal tip, the basal arch with a lightly sclerotized membrane on the distal third.

In the keys by Fox (1955) to the species belonging to the subgenus *Selfia,* neither sex of Texas specimens of this species will key out. The male does not fit since the aedeagus is not separated into two boomerang-shaped plates, and the female because the mesonotal pattern is not uniform brown, but consists of three longitudinal darker brown vittae on a dark brown background, the central one broadened.

Culicoides hinmani Khalaf

Culicoides hinmani Khalaf 1952, Ann. Ent. Soc. Amer. 45:353.
Culicoides borinqueni Wirth 1952b, Proc. Ent. Soc. Wash. 54:238; Snow 1955, Ann. Ent. Soc. Amer. 48:517; Wirth and Jones 1956, Proc. Ent. Soc. Wash. 58:161; Wirth and Bottimer 1956, Mosquito News 16:261. Misdetermination.

New taxonomy.

Previously recorded from: Oklahoma (type locality); Alabama, Snow, Pickard, and Moore (1957) (as *borinqueni*); Tennessee, Snow (1955) (as *borinqueni*); Texas, Wirth and Bottimer (1956) (as *borinqueni*); Virginia, Wirth (1952b) (as *borinqueni*).

Comparison of material previously determined as *borinqueni* Fox and Hoffman (1944) from Texas, Virginia, Tennessee, and Alabama with material from Puerto Rico (type locality) showed that two species were involved. Close examination of the material from the United States disclosed that it was comprised of one species, *hinmani* Khalaf.

The original description of *borinqueni* states "Mesonotum yellowish brown, without darker markings; scutellum of the same color as the mesonotum, legs a yellowish or reddish brown." A redescription by Fox (1949) and a female specimen from Puerto Rico in the U.S. National Museum collection both have the angle of the MC fork in cell M_2 occupied by a light spot which extends posteriorly into cell M_4 along vein Cu_1. The USNM specimen also has the mesonotum definitely yellowish, without darker markings; antennal sensoria present on segments III, V, VII, IX, and XI-XV; and antennal segment XI longer than segments IX and X combined.

The specimens from Texas, Virginia, Tennessee, and Alabama conform to the original description of *hinmani* from Oklahoma, the following primary characters for both contrasting with the description above for *borinqueni:* mesonotum with a dorsal pattern of three longitudinal dark vittae, scutellum darkened centrally, legs with distinct light banding, wing with the light spot in the angle of the MC fork contained entirely in cell M_2, antennal sensoria present on segments III and XI-XV, and antennal segment XI shorter than segments IX and X combined.

A redescription of the female of *hinmani* Khalaf based on Texas material is as follows. Where Khalaf's original description differs from this, it is parenthetically included in quotes.

Female: Wing length 0.8 mm., width 0.4 mm. Head dark brown, antenna and proboscis lighter, palpus distinctly very pale; eyes contiguous ("eyes practically touching"). Antennal ratio (combined lengths of last five segments divided by combined lengths of the preceding eight) 1.3, segments longer than wide; segments IX plus X and XI-XV in ratio of 1.3, 1, 1.0, 1.1, 1.2, 1.7; sensoria present on segments III and XI-XV. Palpus with third segment slightly swollen with moderately large and deep sensory pit. Proboscis short, the ratio of height of head minus proboscis divided by length of proboscis 1.8; mandible with about 13 very small teeth.

Mesonotal disc greyish to reddish brown, with three longitudinal, usually distinct, dark brown vittae anteriorly; prescutellar dark spots indistinct; scutellum dark brown centrally, the sides concolorous with mesonotal ground color. Legs brown with distinct light banding; femora with basal light bands, knees narrowly darkened with narrow light bands above and below, hind tibia with broad apical light band; hind tibial comb with four large spines.

Wing with second radial cell included in dark spot, macrotrichiae sparse, color light brown with the following well defined light spots; a small rounded one on crossvein, extending broadly to costa anteriorly and barely extending through vein M_{1+2} posteriorly; a doubled light spot at apex of second radial cell, the posterior half situated more basad and attaining fold above vein M_1; an apical transverse row of three rounded light spots well separated from wing margins, one each in cells R_5, M_1, and M_2; a light spot in cell M_4, attaining vein M_{3+4} anteriorly and wing margin posteriorly; a transversely doubled light spot in apex of anal cell ("one in tip of anal cell"), the posterior half confluent with a light area bordering the anal angle of wing; one basad in anal cell, more or less confluent with light area at base of wing; a light spot at base of cell M_1, well separated from vein M_1 and broadly attaining vein M_2, occasionally a small indistinct light spot situated posterior to cell M_2, vein M_2 lying in a dark area ("one on vein M_2 interrupted by the vein, and the larger part of the spot in cell M_1"); a light spot occupying the angle of MC fork in cell M_2, not crossing veins posteriorly ("a small one just before the forking of vein Cu_1"); an elongated light spot on longitudinal axis of cell M_2 basally, extending indistinctly from light area at base of wing to between light spots on crossvein and above MC fork and distinctly separated from them; veins M_1 and M_2 obscurely light bordered; and veins M_{3+4} and Cu_1 lying in dark areas, in some specimens terminating in obscurely lighter areas at wing margin. Crossvein light yellow, indistinct; haltere knob bright yellow.

Abdomen brown, cercus a lighter brown. Spermathecae two, oval, subequal, medium-sized, lightly sclerotized, ducts sclerotized for a short distance; rudimentary spermatheca and ring present.

The genitalia of specimens from Texas, Virginia, and Alabama agree with those of specimens from Oklahoma except for apparently minor differences. Their conformation differs from that of the original drawing in the following particulars: paramere with stem not as swollen as indicated, tapering evenly to a long, slender, sinuate tip, the base with end slightly

knobbed; aedeagus with basal arms turned outward anteriorly; and ventral root distinctly slender.

Culicoides loughnani Edwards

Culicoides loughnani Edwards 1922, Bull. Ent. Res. 13:165.

New State record.

Aransas Co. light trap (Table I).

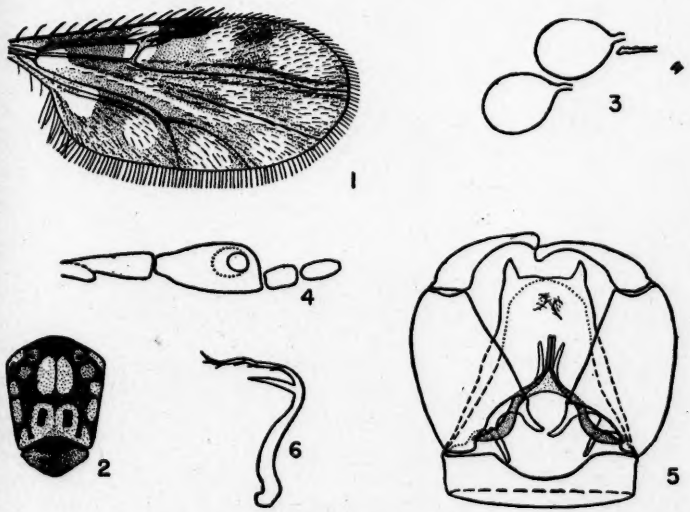
Previously recorded from: Jamaica (type locality); Florida, Beck (1952).

Culicoides luglani, new species

Culicoides new species near *haematopotus*, Wirth & Bottimer 1956, Mosquito News 16:265.

A medium-sized species; mesonotum and wing with a distinct pattern of markings, second radial cell included in a dark spot; male genitalia distinctive.

Female: Wing length 1.0 mm., width 0.5 mm. Head dark brown, proboscis and palpus dark brown, antenna lighter brown, eyes separated. Antennal ratio 1.0; segments stout, longer than wide, segments IX plus X, and XI to XV in ratio of 1.5, 1, 1.0, 1.1, 1.1, 1.6; sensoria very distinct on segments III to X, absent or indistinct on segments XI to XV. Palpus (fig. 4) with third segment distinctly swollen, with moderately large, deep sensory pit, the opening round and distinct. Proboscis short, ratio of height of head minus proboscis divided by length of proboscis 1.7; mandible with 13-15 small to very small teeth.



Culicoides luglani new species

Fig. 1, wing. Fig. 2, mesonotal pattern. Fig. 3, spermathecal system. Fig. 4, palpus. Fig. 5, male genitalia, parameres removed. Fig. 6, paramere, lateral view.

Mesonotal disc (fig. 2) with distinct pattern of light areas on dark brown background as follows: a median pair of oval light spots on anterior one half, these narrowly separated and usually small; a darker, indistinct, rounded pair laterad of median pair, midway between lateral margins and median line; two pairs of elongate light spots close to lateral margins on posterior two thirds, consisting of two spots on each side in longitudinal line; a large pair of rounded spots, indistinctly separated on median line, enclosing the dark brown prescutellar dark spots; the posterolateral corners light in color, these posteriorly narrowly confluent with light areas surrounding the prescutellar dark spots; and the anterolateral corners light with a light area extending narrowly around each humeral pit. Scutellum dark brown centrally, sides lighter. Legs dark brown with distinct light banding; femora at most slightly lightened basally, knees broadly dark brown, with narrow light bands basad and distad to them, hind tibia with broad light band apically; hind tibial comb with four large spines.

Wing (fig. 1) with second radial cell included in dark spot, macrotrichiae moderately dense, color brown with the following well defined light spots: one on crossvein extending broadly to costa and posteriorly extending slightly through vein M_{1+2}; one at apex of second radial cell, extending basally slightly under cell and posteriorly to fold above vein R_5, distal margin slightly indented; a large oval light spot apically in cell R_5, and a smaller one apically in cell M_1, these two indistinctly separated from wing margin; a medium-sized light spot apically in cell M_2, attaining wing margin; a large light spot in cell M_4, broadly attaining wing margin posteriorly and vein M_{3+4} anteriorly; a basal and an apical light spot anteriorly in anal cell, both rounded with apical spot larger, the anal cell posterior to these light spots indistinctly lightened; a light spot basally on vein M_2, bulk of light spot in cell M_1, posteriorly narrowly connected with light line extending basally along median axis of cell M_2; this light line expanded into a small light spot in cell M_2 under crossvein; a small light spot occupying base of wing; veins M_1 and M_2 bordered with lighter areas beyond apex of second radial cell; and veins M_{3+4} and Cu_1 lying in dark areas. Crossvein light colored, slightly darker than surrounding light spot. Halter knob white, stem browned.

Abdomen brown, cercus a lighter brown. Spermathecae (fig. 3) two, oval, subequal, medium-sized, moderately sclerotized, with duct sclerotized for one sixth length of spermatheca; rudimentary spermatheca and ring present.

Male: Similar to the female with the usual sexual differences. Genitalia (figs. 5-6). Ninth sternum moderately and evenly emarginate, membrane not spiculate; ninth tergum strongly tapered to apex, apicolateral processes well developed. Basistyle normal; ventral and dorsal roots well developed and subequal, ventral root slightly arcuate and moderately stout, dorsal root straight and moderately slender. Aedeagus as figured, apex obscure, apparently with four long, lightly sclerotized fingers. Parameres separate: each with base slightly knobbed; the moderately stout stem evenly tapering to slender, recurved tip which is armed with a few stout, short spines; stem armed with a stout, long spine basad and adjacent to recurved tip.

Types. Holotype, ♀ (pinned): USDA Expt. Sta., Kerr Co., Texas, light trap, 25 VIII 1956, R. H. Jones. (Type No. 63406 USNM.) *Allotype,* ♂ (slide, Jones No. 3433): same data as holotype except 25 IX 1956. *Paratypes,* 41 ♀ ♀, Kerr Co., Texas, light trap: 23 ♀ ♀ same data as holotype except date (1 ♀ 10 VIII, 1 ♀ 17 VIII, 1 ♀ 24 VIII, 2 ♀ ♀ 25 VIII, 1 ♀ 1 IX, 1 ♀ 2 IX, 1 ♀ 3 IX, 3 ♀ ♀ 6 IX, 1 ♀ 7 IX, 1 ♀ 9 IX, 2 ♀ ♀ 10 IX, 2 ♀ ♀ 11 IX, 1 ♀ 12 IX, 2 ♀ ♀ 15 IX, 2 ♀ ♀ 19 IX, 1 ♀ 25 IX); 1 ♀ W. C. Schwethelm ranch, 17 VIII 1956, Jones; 17 ♀ ♀ Kerrville (1 ♀ X 1953, 1 ♀ 8 XI 1953, 2 ♀ ♀ 29 IV 1954, 1 ♀ 21 V 1954, 11 ♀ ♀ V 1954, 1 ♀ 22 VII 1954), L. J. Bottimer. *Paratypic specimen,* 1 ♂ (pinned), same data as holotype except 6 IX 1956, genitalia lost.

This species is not particularly closely related to any other North American species. Its closest relative is probably ***haematopotus*** Mall.

Culicoides stonei James

Culicoides stonei James 1943, Pan-Pacific Ent. 19:149.

Culicoides weesei Khalaf 1952, Ann. Ent. Soc. Amer. 45:351; Khalaf 1952, Jour. Kansas Ent. Soc. 25:65; Khalaf 1954, Ann. Ent. Soc. Amer. 47:38; Fox 1955, Puerto Rico Univ. Jour. Agri. 39:223; Wirth and Bottimer 1956, Mosquito News 16:264. New synonymy.

The dissection of a male paratype of *C. stonei* James in the collection of the United States National Museum showed that the genitalia were identical to those of *C. weesei* Khalaf. Both species possess characteristic spines on each side immediately below the apicolateral processes in a sac-like expansion of the sclerotized border of the ninth tergum. This character was not indicated in the original description of *stonei,* and was the distinctive character separating these two species. Examination of the holotype ♂ showed that it possessed these spines.

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THE DISCOVERY OF *ORTHOPODOMYIA SIGNIFERA* (COQUILLETT) AND *ANOPHELES BARBERI* COQUILLETT IN MINNESOTA (Diptera, Culicidae)[1]

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Collections by one of the authors (LRA) from tree holes and stump holes during the fall of 1957 revealed the presence of *Orthopodomyia signifera* (Coq.) and *Anopheles barberi* Coq., two species of mosquitoes not previously reported as occurring in Minnesota.

Five pupae of *O. signifera* were taken from a stump hole of what was possibly an elm in Scott Co., Sept. 17; eight late fourth-instar larvae were taken from one tree hole at the base of a medium-sized elm and six pupae and three very late fourth-instar larvae were taken from a similar type of tree hole in another elm in Dakota Co., Sept. 22. This species occurred in association with *Aedes triseriatus* (Say). *O. signifera* has been reported previously from the adjacent states of Iowa and North Dakota (Carpenter and LaCasse, 1955), and the ease with which this species was taken in Minnesota would suggest that it is more widespread in the northern portion of its range than previously known. Matheson (1944) reported that *O. signifera* larvae were unable to survive freezing; in view of this and the fact that late fourth-instar larvae and pupae were found in Minnesota late in September, it is possible that in this area the species overwinters in either the adult or egg stage.

A total of 13 *A. barberi* larvae were taken on Sept. 8 and Sept. 17 in Scott Co., collections on both dates being from the same hole in a fallen burned-out tree trunk (elm?) in a wooded pasture. The larval associates consisted of *A. triseriatus* and *Culex restuans* Theob. The northern boundary of *A. barberi* distribution was known to run from southcentral New York through northern Illinois and central Iowa (Jenkins and Carpenter, 1946) and these same workers theorized that this limitation was probably due to the ". . . cold temperatures and long winters through which the larvae must survive." This Minnesota record probably represents the most severe climatic conditions that this species is known to breed in. The finding of early instar larvae on these dates would seem to be in agreement with the statement of Matheson (1944) that second-instar larvae overwinter frozen solidly in ice.

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[1] Paper No. 3850 Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota.

EFFECT OF THE FEEDING OF THE FOUR BIOTYPES OF CORN LEAF APHID, *RHOPALOSIPHUM MAIDIS* (FITCH) ON SUSCEPTIBLE WHITE MARTIN SORGHUM AND SPARTAN BARLEY PLANTS[1]

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The corn leaf aphid, *Rhopalosiphum maidis* (Fitch) is one of the major pests of corn, sorghum and barley. It feeds mostly on the growing parts of the plants, in the central leaf whorl, under leaf sheaths, emerging sorghum heads, and developing tassels of the corn plants. The damage is due to the constant drainage of the plant liquids through feeding, much of which may be excreted as honey dew. The honey dew deposited on the plant surface furnishes a substrate for fungus growth, interferes with normal pollination of the flowers, and attracts corn earworms on corn and sorghum plants. Feeding of the corn leaf aphid may cause the wilting of the leaves and occasionally death of the plants. Painter (1951) stated that the damage done by the corn leaf aphid was less evident than that done by many other insects that actually may be of less importance. He further reported that the feeding of the aphids on corn causes serious physiological effects on the plants, one of the results being the retardation or prevention of development of the ear shoot. The first quantitative estimate of the corn leaf aphid damage was reported by McColloch (1921) who stated that feeding may cause a loss of 53% in weight and 50% in volume of seeds in the head of the Kafir sorghum. Wildermuth and Walter (1932) reported it was the most serious pest of barley in the Southwestern United States. Apparently no study has ever been made measuring the damage caused by the aphids to the roots and tops of the plants.

The present work was undertaken in order to find the possible differences in effects of the feeding of the four biotypes of corn leaf aphid on plant heights and on the root weights and top weights of the two susceptible hosts. The hosts used were Spartan barley and White Martin sorghum plants. The details regarding the origin and other distinguishing characters of the four biotypes of corn leaf aphid will be reported in another paper.

MATERIALS AND METHODS

Howitt and Painter (1956), in their tests of the world germ plasm of the sorghums available in the United States for corn leaf aphid reactions, reported White Martin as the most susceptible variety to this insect. In the spring of 1956, 25 winter barley varieties and 21 spring barley varieties were tested by the writers in the greenhouse for their reaction to corn leaf aphid. Among these, Spartan, a spring barley, proved to be the most susceptible.

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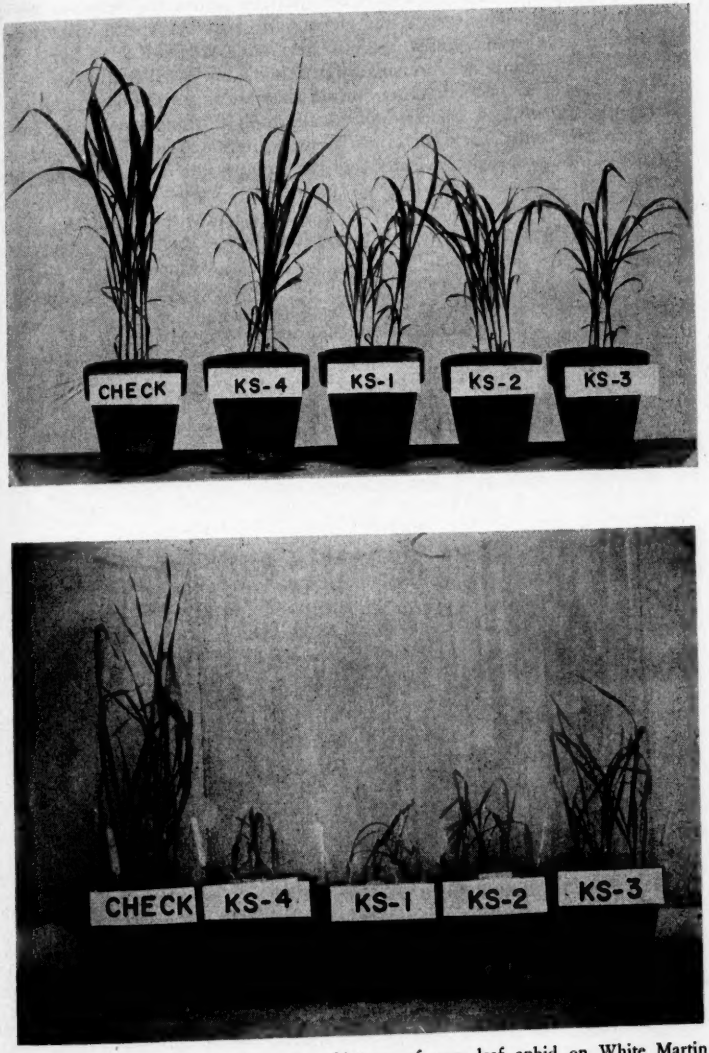
Since then these two varieties have been used as susceptible checks and as culture plants for maintaining corn leaf aphid populations. These two varieties because of their high susceptibility were also selected for the present studies.

About ten seeds of each of the two varieties were sown separately in each of the five, six-inch flower pots in the greenhouse where the temperature was maintained at approximately 70° F. The soil used was a mixture of six parts black loam, one part sheep manure, and one part sand. These components were mixed thoroughly and passed through a ¼ and later a 1/16-inch wire mesh screen. At the two-leaf stage of growth, individual pots were thinned to five plants of approximately the same size. In each variety, the plants in each of four of these pots were infested with 30 apterous adults of one of the four biotypes of corn leaf aphids. Plants in the fifth pot seved as control. Both the control and infested plants were enclosed in cellulose nitrate cages five and one-half inches in diameter and 20 inches high. The tops of these cages were covered with nylon-orlon cloth and each of the cages was provided with four nylon-orlon covered windows. The plants were numbered individually and their heights recorded every tenth day. The experiment was allowed to continue for a month and each experiment was replicated three times. The heights of the plants, dry weights of the shoots (hereafter referred to as top weights) and the dry weights of the roots were recorded at the end of the experiment. After taking the final height records all the aphids on the plants were killed by spraying with a nicotine sulphate solution. The soil of the pots was then thoroughly soaked in water and the roots carefully freed of soil. Individual plants were then separated from each other and the roots were detached from the top at the junction of the two parts. The roots and the tops were kept separately in numbered polystyrene rectangular boxes and the excess moisture from them was allowed to evaporate for two to three days. These plant parts were dried in a 56° C. oven for 14 days, removing almost the last trace of moisture from them. The dry weights of the roots and tops of the individual plants were then taken separately on a Roller-Smith precision balance with a sensitivity of .02 milligrams. This whole procedure was repeated three times for each host with similar results. No count of the number of aphids present was made because with some of the higher levels of damage the number of aphids present probably was reduced beyond an earlier peak population. The number of aphids present on a plant probably decreased with the advance of the damage because of the reduction in the quality and quantity of available plant material.

The stock cultures of the four biotypes of corn leaf aphids were from those regularly maintained on Spartan barley plants grown in pots and caged separately in cellulose nitrate cages.

RESULTS

The information and discussion which follow are based primarily on the averages given in the tables. As is shown in the figures, the four biotypes differed in the extent of damage caused to the two host plants. In separate tests the four biotypes reproduced at almost the same rate on Spar-



Effects of the feeding of the four biotypes of corn leaf aphid on White Martin Sorghum plants (above) and on Spartan Barley plants (below).

tan barley plants (Table 1). On White Martin plants, the biotypes KS-1, KS-2, and KS-4 had almost equal fecundity rates but the biotype KS-3 reproduced at a significantly higher rate than biotype KS-1 (Table 1). Though there was this difference in fecundity on White Martin, yet, as is discussed later, these two biotypes did not show any significant difference in damage to this host. On Spartan barley, although all the biotypes had about the same fecundity, they did show some differences in the amount of damage. This apparently indicates that the fecundity of the aphids was not related to the damage on different host plants. In another experiment, Pathak and Painter (1958) found that on White Martin plants the amount of plant material taken was also not related to the fecundity of the different biotypes.

TABLE 1

Fecundity* of single viviparous alate females of each of the four biotypes of corn leaf aphids, *Rhopalosiphum maidis* (Fitch) on White Martin sorghum and Spartan barley plants. Manhattan, Kansas, 1956-57.

Plant	Average number of aphids produced by biotypes			
	KS-1	KS-2	KS-3	KS-4
White Martin Sorghum	12.5	15.4	17.3	14.3
Spartan Barley	19.3	18.3	18.1	20.8
lsd at 5% level for White Martin = 4.2				
No significant difference at 5% level for Spartan barley				

*Average based on 10 replications each after feeding for 10 days.

It is evident from Table 2 that the heights of all White Martin and Spartan plants, caged with different biotypes of corn leaf aphids were significantly lower than the uninfested plants used as control. On White Martin biotype KS-4 caused the least reduction in heights and the plants caged

TABLE 2

Effect of feeding of 30 apterous adults of the four biotypes of corn leaf aphid on the heights in inches of White Martin sorghum and Spartan barley plants. The plants were infested at the two-leaf stage of growth and final records were made after one month. Manhattan, Kansas, 1956-57.

Host plant and Replication Number		Biotypes				
		KS-1	KS-2	KS-3	KS-4	Uninfested Check
White Martin Sorghum	*1	15.7	16.20	15.60	18.70	24.40
	*2	11.40	13.50	11.50	16.00	21.40
	*3	11.70	14.50	11.90	16.60	21.20
Average		12.73	14.73	13.00	17.10	22.33
% of Check		57.01	65.97	58.22	76.58	.....
lsd at 5% level of significance for individual replications = 1.80						
lsd at 5% level of significance for average = 1.04						
Spartan Barley	*1	12.00	12.00	13.00	10.80	22.00
	*2	11.40	12.20	18.70	13.20	22.70
	*3	14.10	14.60	17.50	14.10	24.20
Average		12.50	12.93	16.40	12.70	22.97
% of Check		54.42	56.29	71.40	55.29	.....
lsd at 5% level of significance for individual replications = 2.84						
lsd at 5% level of significance for average = 1.64						

*Each replication represents an average for five plants grown in the same pot.

with biotypes KS-2 were less affected than the plants with biotypes KS-1 and KS-3. The differences in the heights of the plants between biotypes KS-1 and KS-2, and KS-2 and KS-3 were significant but those between biotypes KS-1 and KS-3 were not. The heights when expressed as percentage of the heights of the check plants varied from 57.0 to 76.6%. The four biotypes can be arranged: KS-1, KS-3, KS-2, KS-4, in descending order of damage caused.

Biotype KS-4 which caused the least stunting of White Martin plants produced almost the maximum stunting on Spartan plants. Biotype KS-3 had the least effect on the heights of the Spartan plants, the difference being significant from all other biotypes, which did not show any significant differences among themselves. The heights of the Spartan plants caged with the aphids when expressed in terms of the percentage of the heights of the control plants varied from 54.4 to 71.4%. The four biotypes can be arranged: KS-1, KS-4, KS-2, KS-3, in descending order of damage caused. This indicates that the aphids caused almost the same degree of reduction of the heights of both White Martin and Spartan plants but the sequence of the different biotypes when arranged in order of their damage was different on the two hosts.

Table 3 gives the dry top weights of the White Martin and Spartan. The top weights of the control plants were always significantly greater than the top weights of the aphid infested plants. The heights of the White Martin plants caged with KS-2 and KS-3 were significantly different while the top weights were not quite significantly different. The order of these four biotypes when arranged according to their damage to tops was the same as on height basis. The top weights of the plants as expressed in terms of the percentage of the check plants varied from 26.7 to 46.1%. This indicates that the feeding of the different biotypes was evident more in the top weights than in the heights of the White Martin plants. On Spartan barley also, the sequence of the four biotypes when arranged according to their top weight loss was the same as with the heights but there were some variations in the extent of damage. All control plants weighed far more than the plants caged with any of the biotypes. Though the plants with KS-1, KS-2 and KS-4 did not show a significant difference in their heights, the plants caged with biotype KS-2 weighed significantly heavier than the plants with KS-1. There was no significant difference between the top weights of the Spartan plants caged with biotypes KS-2 and KS-4. Biotype KS-3 was the least destructive to the top weights of the Spartan barley plants and caused significantly less loss than the biotypes KS-1 and KS-4 but not KS-2. The top weights of the Spartan barley plants caged with different biotypes, when expressed as percentages of the check plants, varied from 14.1 to 26.3%. The percentage loss also indicates that the aphids caused relatively more damage to barley than to the sorghum plants. The heights of the plants did not appear to have a close relation to the top weights of the plants since the heights of Spartan barley plants containing KS-1, KS-2, and KS-4 did not differ significantly, yet they showed significant differences in the top weights. This might suggest a greater tolerance of the host for certain biotypes of the aphid.

TABLE 3

Effect of feeding of 30 apterous adults of each of the four biotypes of corn leaf aphids. Top weights are in milligrams of White Martin sorghum and Spartan barley plants. The plants were infested at the two-leaf stage of growth and final records were made after one month. Manhattan, Kansas, 1956-57.

Host Plant and Replication Number		Biotypes KS-1	KS-2	KS-3	KS-4	Uninfested Check
White Martin Sorghum	*1	139.72	150.32	158.96	263.04	506.20
	*2	130.16	158.12	138.68	206.76	484.56
	*3	131.52	174.12	131.36	221.28	510.52
Average		133.80	160.85	141.33	230.56	500.43
% of Check		26.74	32.14	28.24	46.07	.....
lsd at 5% level of significance for replications = 41.53						
lsd at 5% level of significance for averages = 23.98						
Spartan Barley	*1	37.76	52.68	59.20	33.52	234.00
	*2	35.48	59.88	68.72	43.32	272.96
	*3	30.54	54.28	64.84	36.96	226.60
Average		34.59	55.61	64.25	37.93	244.52
% of Check		14.15	22.74	26.28	15.51	.....
lsd at 5% level of significance for replications = 31.55						
lsd at 5% level of significance for average = 18.20						

*Each replication represents an average for five plants grown in the same pot.

Table 4 presents the root weights of the check plants and plants caged with different biotypes of the aphid and shows that the root weights of the control plants were significantly heavier than those of the plants caged with any of the biotypes. This shows that the feeding of each of the biotypes on leaves caused severe injury to the roots of the host plants.

TABLE 4

Effect of feeding of 30 apterous adults of each of the four biotypes of corn leaf aphids on the root weights in milligrams of White Martin sorghum and Spartan barley plants. The plants were infested at the two-leaf stage of growth and final records were made after one month. Manhattan, Kansas, 1956-57.

Host Plant and Replication Number		Biotypes KS-1	KS-2	KS-3	KS-4	Uninfested Check
White Martin Sorghum	*1	11.88	22.44	11.56	21.24	97.60
	*2	9.84	14.36	9.88	17.32	99.04
	*3	9.08	12.68	9.92	16.66	105.96
Average		10.27	16.49	10.45	18.37	100.87
% of Check		10.18	16.35	10.36	18.21	.....
lsd at 5% level of significance for replications = 11.64						
lsd at 5% level of significance for average = 6.72						
Spartan Barley	*1	2.68	5.16	6.44	2.72	35.20
	*2	4.56	9.16	13.76	4.68	49.36
	*3	3.96	8.66	13.80	6.28	31.12
Average		3.73	7.66	11.33	4.56	38.56
% of Check		9.67	19.87	29.38	11.83	.....
lsd at 5% level of significance for replications = 3.98						
lsd at 5% level of significance for average = 2.30						

*Each replication represents an average root weight of five plants grown in the same pot.

Biotype KS-4 caused significantly less damage to the roots of the White Martin plants than did KS-1 and KS-3. Biotype KS-2 caused more damage to the roots than KS-1 and KS-3 and less than KS-4 but in this it did not differ significantly from any of the biotypes. The root weights of the White Martin plants caged with different biotypes, when expressed as percentages of the root weights of the check plants, varied from 10.2 to 18.2%. The four biotypes can be arranged according to their root damage on the White Martin plants as on the basis of reduction in the heights of the plants or injury to the top weights of the plants. A larger percentage of loss to the root weights of the plants also suggested that the damage caused by different biotypes of corn leaf aphids to the roots of the White Martin plants was even more severe than the damage caused to either the top weights or heights of the plants.

All four biotypes also caused a significant damage to the roots of the barley plants. The roots caged with biotype KS-3 weighed significantly the heaviest of the group, while the roots of the plants with biotype KS-2 weighed heavier than those with biotypes KS-1 and KS-4 which did not differ significantly among themselves. The root weights of the Spartan barley plants, caged with different biotypes, when expressed as percentage of the root weights of the check plants, varied from 9.7 to 29.4%. The four biotypes can be arranged: KS-1, KS-4, KS-2, KS-3, in descending order of their damage. This sequence is the same as that according to heights or the top weights of the Spartan barley plants.

DISCUSSION

The four biotypes differ in their damage to White Martin sorghum and Spartan barley plants. This difference in damage was not related to the fecundity of the different biotypes on different host plants. On Spartan barley plants all the four biotypes had almost the same fecundity, but they showed significant difference in their damage so that the tops of the plants caged with KS-1 and KS-4 weighed little more than half as much as the tops of the plants caged with KS-3. The roots of the plants caged with biotype KS-3 weighed almost three times as much (11.33) as roots of the plants caged with biotypes KS-1 and KS-4 (3.73 and 4.56 respectively). On White Martin plants biotype KS-3 reproduced at a higher rate than KS-1 but there was no significant difference in the fecundity of any of the other biotypes. The biotypes KS-1 and KS-3 did not show any significant difference in the injury caused to the plants. Thus on both hosts the damage by the aphids did not correspond to their fecundity. This suggests that the number of the aphids present is not as important in causing damage as the physiology of the aphids, physiology of the plants, or host-insect interaction. Equal number of aphids but differences in damage is a classical example of tolerance (Painter 1951). Hence, the two hosts show variations in their tolerance to different biotypes.

The feeding of all the four biotypes caused significant stunting to both White Martin sorghum and Spartan barley plants. The different biotypes did not behave the same way on both plants. On White Martin plants the four biotypes can be arranged as KS-1, KS-3, KS-2, KS-4 in descending

order of damage, but on Spartan barley this sequence was KS-1, KS-4, KS-2, KS-3. Biotype KS-1 was the most destructive to both hosts. The extent of stunting caused was almost the same on both White Martin and Spartan barley plants with the different biotypes having different positions on two hosts. Both the roots and tops of the control plants weighed significantly more than the plants caged with any of the biotypes. The sequence of damage shown was the same as on the heights but the per cent loss of top weights was greater than the stunting effect. This indicates that the infested plants besides showing a stunting effect are also greatly weakened. The top weights of the infested White Martin plants as expressed in terms of percentage of control plants varied from 26.7 to 46.1% while for Spartan barley plants it varied from 14.2 to 26.3%. This shows that even though the heights of both White Martin and Spartan plants were affected the same way, the top weights of barley plants were more affected. Though on Spartan barley, KS-1, KS-2, and KS-4 did not cause a significant difference in heights, significant differences were found in their top weights. This indicates that the heights of the plants may not be related to the top or root weights.

All four biotypes also caused a consistent and highly significant injury to the roots of the two hosts studied. The sequence of damage by the four biotypes to the roots of the plants was almost the same as the sequence of the heights and top weights of the two hosts. The root weights of the infested plants expressed as percentage of the control plants varied from 10.2 to 18.2% for White Martin and 9.7 to 29.4% for Spartan plants. Thus the root systems of both hosts were severely affected by the feeding of aphids on the leaves. In general, barley plants were more affected than sorghum plants and the aphids caused more damage to the roots of the plants than the stunting or reduction in top weights.

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A NEW SPECIES OF *HYSTEROPTERUM* FROM GRAPE (Issidae, Fulgoroidea, Homoptera)[1]

KATHLEEN C. DOERING

The present paper includes a description of a new species of *Hysteropterum*, described mainly from specimens reared on grape in a locality 1.5 miles south of Asti, California, by Doctor Evert I. Schlinger. Dr. Schlinger's descriptive notes on the interesting egg laying habits and other biology of this insect follow in this issue. *Hysteropterum beameri* was reported by Dr. Schlinger as being very abundant in the type area during 1954. In view of the fact that it has never appeared in any of the numerous collections previously studied by the author, it must be a species of rather sporadic occurrence.

Hysteropterum beameri n. sp.

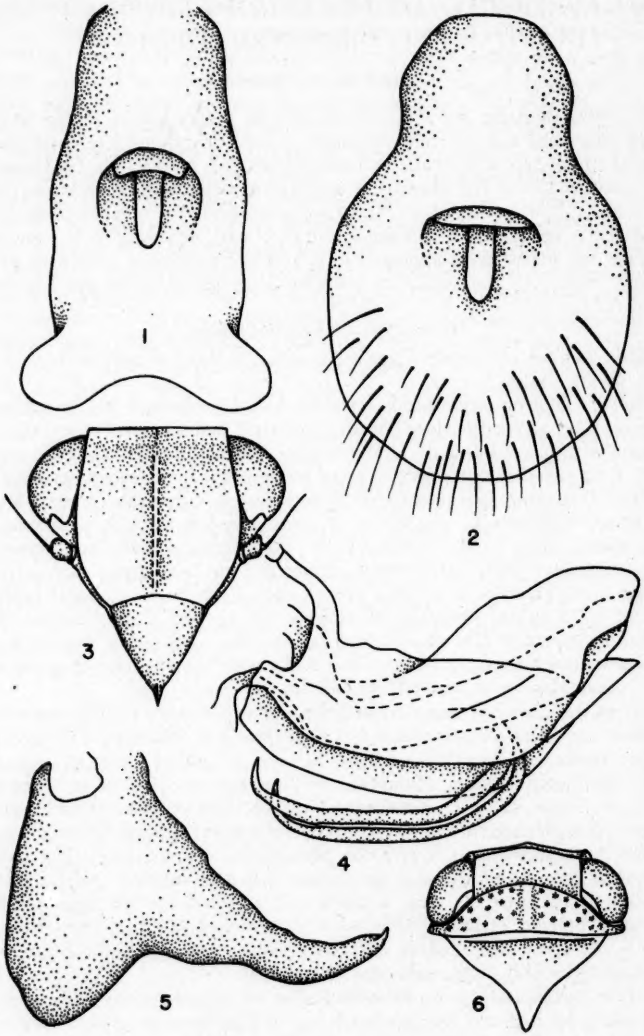
Size: Length of female 5.6 mm., width 3.3 mm.; length of male 4.9 mm., width 3 mm.

Color: Coloring stramineous, anterior half of subcostal cell of tegmen forming a broad cream-colored border, posterior half fuscous brown, clavus clouded with fuscous and apical and subapical areoles mottled fuscous, veins light. Eyes mottled red-brown. Vertex stramineous with indistinct brown splashes. Pronotum stramineous, uniformly dotted with round brown spots. Scutellum stramineous, shaded with dark through middle. Abdominal terga mostly dark. Ventral surface light yellow marked with dark at many points. Discs of frons dark brown peppered with light spots; each lateral border light, punctate with dark brown dots. Each lateral half of clypeus crossed by a stripe consisting of oblique brown bars. Legs yellow with numerous brown streaks and spots of brown, fore and middle femora with a narrow brown streak on anterior half and a wide brown stripe on posterior half; tibiae also striped in yellow and brown.

Structural Details: Vertex rectangular, anterior margin broadly rounded, lateral margins not conspicuously elevated, frons protruding beyond median line of vertex, considerably less than half the length of the latter, disc of vertex shallowly concave. Pronotum without carinae. Disc of mesonotum rugulose. Frons as in *H. auroreum* (Uhler) with only a median carina present, disc on each side flat, basal margin almost straight, posterior margin shallowly emarginate to receive the postclypeus. Tegmen not quite twice as long as greatest width, its shape similar to that of *auroreum* with its dorsal line from a lateral view straight and not concave through middle, posterior margin obliquely sloping, a pronounced bulla at base of vein $Sc_2 + R$, costal cell broadly reflexed against venter and this cell about one-half the width of the subcostal cell.

Male Terminalia: In situ tip of aedeagus not exposed since apex of tenth segment is bilobed and does not reach tips of parameres as in *auroreum* and other species. From a flattened dorsal view tenth segment tubular for a third of its total length, posterior to this its lower margin is then extended caudad as a wider plate-like extension (anal flap) which becomes strongly

[1] Contribution no. 1007, Department of Entomology, University of Kansas.



EXPLANATION OF FIGURES

Hysteropterum beameri n. sp.: 1. flattened dorsal aspect of anal segments (tenth and eleventh) of male; 2. dorsal aspect of female anal segments; 3. frontal aspect of head of female; 4. left view of aedeagus and theca; 5. flattened lateral view of paramere; 6. dorsal aspect of head and thorax of female.

bilobed at apex with a broad and deep concavity occurring between two apical lobes. Posterior to semi-circular dorsal margin of tenth segment, an annular eleventh segment and stylus are exposed.

Parameres in situ from ventral view appear as two pointed flat plates, meeting at midline. At sides they curve around the aedeagus and their dorsal arms extend to the latero-apical lobes of tenth segment. In flattened lateral view each paramere approximately twice as long on ventral margin as its basal width; on its dorsal side extended dorsad into a long arm-like process which is much longer than other species of the genus, the arm itself being about twice the width of the plate-like part.

Theca closely ensheathing aedeagus so that externally only two long, slender, well sclerotized processes of aedeagus show; these curved rods emerging one on each side from between upper and lower lobes of theca which is split apically to a distance about one-third of the way back from apex; upper lobe of theca bulging apically, covering tip of aedeagus which seemingly lacks apical hooks; ventral portion of theca extending posteriorly as a single pointed plate which does not quite reach apex of aedeagus.

Female Terminalia: Tenth segment a flattened tube at base as in the male, beyond which on ventral side it is extended into a broad spatulate lobe, the anal flap, which is almost twice as wide as tubular base. Shape of this segment differing from other species as follows: basal annulus bearing a conspicuous constriction halfway from base, from which point it immediately widens into the anal flap; free margins of anal flap parallel-sided, not deflexed, apex broadly rounded.

Comparative Notes: This species resembles *auroreum* (Uhler) in general coloration, having a cream-colored subcostal border in contrast to fuscous-spotted remainder of wing. It is similar to *auroreum* in having a straight anal border of wing, not concave through middle, and in having a straight rod-like aedeagal process as opposed to a bifid one. It differs from *auroreum* by the following: frons flat, clypeus likewise flat and not invaginated into frons, in dorsal view frons protruding very little beyond vertex; lateral processes of aedeagus strongly recurved at apex; aedeagus mostly hidden by theca and without apical hooks; paramere with dorsal arm slender and much longer than basal width while in *auroreum* the arm is one-half of basal width; anal flap of male distinctly bilobed, central third of apical margin deeply concave, while *auroreum* is trilobed, with median lobe prominently projecting caudad.

Location of Types: Described from 13 specimens reared at a location 1.5 miles south of Asti, California, Sonoma county, California by Dr. Evert Schlinger, January, 1954.

Holotype male, allotype female and paratypes in the Snow Entomological Museum; other paratypes in the California Academy of Sciences, San Francisco, the University of California, Davis, California, and the private collection of Dr. Schlinger, Riverside, California.

NOTES ON THE BIOLOGY OF A MUD EGG-CASE MAKING FULGORID, *HYSTEROPTERUM BEAMERI* DOERING (HOMOPTERA:FULGORIDAE)

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The occurrence of this species was first brought to my attention by R. L. Sisson, through Leslie M. Smith, both from the University of California. Mr. Sisson (in litt.) noted that an extremely large population of this unknown insect's mud cases was causing some alarm to grape growers in a restricted vineyard area south of Cloverdale, Sonoma County, California. The following biological observations were carried out on this species at various times during the winter and spring of 1954 while I was a graduate student at the University of California at Davis. Due to other commitments during the spring of that year, I was unable to concentrate on the habits of this species, but when K. C. Doering of the University of Kansas informed me (in litt.) that this was a new species of the genus *Hysteropterum* and that she did not have any literature reference to the peculiar mud egg-case construction habit, I endeavored to gather as much information as possible in the short time then available. Thus, these notes are admittedly sketchy and inconclusive, but it is hoped that they may stimulate interest for others to find out how and under what conditions the eggs are deposited in the mud cases. This species is described by Dr. Doering in the preceding article of this issue of the Journal as *H. beameri*.

Upon entering the infested vineyard on February 1, 1954, one could see the peculiar mud cases commonly on the woody part of the vines, on the vine stakes and on the adjacent telephone poles (fig. 1). The majority of the mud cases were located from about 10 to 30 inches above ground, although some were found as low as 5 inches or as high as 6 feet up on the telephone poles. In searching around this area it was found that only about 10% of the population had emerged by this date. No nymphs were seen near the mud cases, but some were found on the damp ground and a few were seen feeding on the small stems of several species of grass, of which cultivated oats (*Avena sativa* L.) was the most common host. All of the individuals observed were small (1 mm.) first-instar nymphs and were of a light grey color with an obvious, bushy, white-haired tail that was about as long as the entire body. No specimens were seen feeding on the grapevines during the whole period under observation, and it was concluded that this species did not damage grapes or grapevines in any way.

That the mud egg cases were extremely abundant is shown by the fact that a count of those on one grapevine stake (4′ × 2″ × 4″) was 5,680. Using a sample of 100 egg cases, a count of the number of eggs per case showed a range of 6 to 13 with an average of 9.5. The lengths of the egg cases ranged from 2 to 5 mm. (average 3 mm.), while the width varied from 1.5 to 2.5 mm. Since the average number of eggs found per egg mass was 9.5, this indicated there were about 53,900 eggs deposited on this one stake. Several vine stakes were equally covered with eggs and many more

were observed with about one-half as many. The grapevines averaged only about 100 to 200 egg cases, suggesting that the flat surfaces of the stakes were more suitable for egg-case construction.

The mud used to make these egg cases consisted mostly of a fine-grain sand and clay. In the laboratory these cases were found to break up easily in distilled water with a little force of a dissecting needle. It is not known whether or not any salivary secretions were used to cement the mud cases, but at any rate it is known that the normal amount of winter rain which had just preceded my observation did not in any way harm the cases.

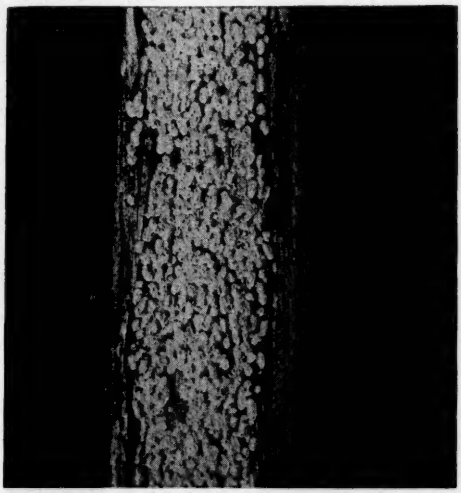


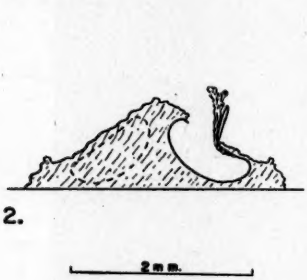
Fig. 1. Mud egg cases of *Hysteropterum beameri* Doering on grapevine stake. About ⅓ natural size. Photograph by H. Kido.

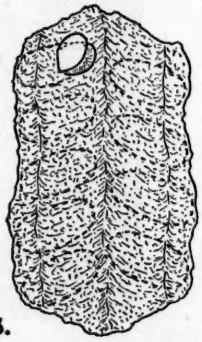
The question of how the adult fulgorid managed to carry the mud up onto the stakes and make the egg cases was not solved. It was found that the adults were not good flyers; however, they were remarkably good jumpers. They walked little without jumping, and when walking seemed to move in short spurts. It seems probable that the adult female carried the mud with her in small quantities as she walked or jumped to the oviposition site. Judging from the structure of the egg case, it appeared as though from five to fifteen individual mud-gathering trips were necessary to complete one case. It is not known how many egg cases are constructed by one female, since I was unable to obtain any egg production or mud-case construction during my preliminary laboratory investigations.

The evidence at hand showed that eggs were deposited singly in two unevenly opposing rows, each egg being laid at about a 30° angle with the head end up (figs. 2 and 3). The eggs were completely covered by mud and when first observed were all white and fairly transparent. Later on they

turned orange, and just prior to emergence the developing nymph was clearly visible. Measurements of a sample of 100 eggs showed a range in length of 0.95 to 1.10 mm. with an average length of 0.98 mm. The width varied only from 0.50 to 0.60 mm. The developing first-instar nymphs rest venter up, and emergence is effected by their cutting out the ventral upper part of the egg. The incision continues down each side about one-half the egg length, and when the nymph emerges the first-instar skin is shed and left attached to the operculum (fig. 2).

Laboratory rearings from the first instar to the adult stage required about sixty days when fed on oats under greenhouse conditions at Davis. Adult longevity ranged from two to three weeks under these conditions. Copulation was not observed and dissection of several two-week-old females revealed no eggs. No egg cases were constructed so that it is not known whether the female lays her eggs during the spring following emergence or whether she may aestivate during the warm, dry summer and lay her eggs in the fall.





Hysteropterum beameri Doering. Fig. 2, Cross section of egg case showing hatched egg on right with first-instar skin attached to operculum. Fig. 3, Dorsal view of egg case showing placement of eggs and hatched egg at upper left.

The only parasite reared from the eggs of this species was a mymarid of the genus *Gonatocerus*. Since parasites of the family Mymaridae are well known egg parasites of homopterous insects, and since parasitization by this *Gonatocerus* species on these eggs was only about 5% during February, 1954, as based on about 1,000 randomly selected eggs, one might theorize that normally this fulgorid species is not common due to natural enemies, which, in this particular year, had failed for unknown reasons. Although I was not present to investigate the situation from 1955 on, I have not heard of any reports from the original or other areas pertaining to similar outbreaks of this insect with its curious mud egg-case making habit.

I would like to thank Dr. K. C. Doering for identifying and describing the fulgorid, and also Dr. R. L. Doutt, University of California, Albany, for identifying the parasite involved.

A NEW SPECIES OF RAKE-LEGGED MITE FROM MISSOURI (Acarina, Caeculidae)[1]

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On December 4, 1954, while collecting along the Missouri River in Boone County, Missouri, Dan M. Stout captured a large mite under rocks which had broken away from the almost perpendicular face of a limestone bluff. On examination it was found to belong to the mite family Caeculidae. Further intensive search under slabs of rock which could be pried loose from the bluff resulted in the capture of more than a hundred specimens. These were subsequently determined to be members of an undescribed species of the genus *Caeculus*.

These mites are easily collected under rocks because they are relatively large, move rather slowly, or remain quite motionless and feign death when disturbed. However, their coloration is dull and on slightly damp rocks they are easily overlooked. The greatest concentrations we found were behind rocks which were difficult to separate from the parent bluff. The site was quite dry but nevertheless small numbers of Collembola were present under some of the rocks.

At the present time eighteen species of *Caeculus* are recorded from North America. Banks (1899, 1906), Nevin (1943, 1945), Mulaik (1945), and Mulaik and Allred (1954) have described, respectively, two, one, ten, and five of the known species. The distribution records include the District of Columbia, Virginia, North Carolina, Alabama, Tennessee, Texas, Puerto Rico, Mexico, New Mexico, Arizona, Utah, Nevada, California, and Oregon. The new species here described extends the range into the north central states for the first time.

The genus *Caeculus* was erected by Dufour in 1832. Its members are easily recognizable by the characters of the legs and dorsal plates as illustrated in Plate I.

Caeculus cremnicolus n. sp.

ADULTS. Length dorsally from apex of propodosomal plate to apex of opisthosoma varying from 1.4 mm. to 2.0 mm. (average of 20 specimens 1.72 mm.); dorsal width above coxae IV varying from 0.85 mm. to 1.43 mm. (average of 20 specimens 1.14 mm.). Gnathosoma and legs black, spines of legs pale translucent yellow. Body plates variable, black to brown, setae pale yellow. Integument between plates cream colored with irregular wavy brown striations. Large membranous articulations between coxae and trochanters white. Legs I seven-segmented, long straight spines on mesal (medio-ventral) margin arranged as follows: two on each tibia; two on each genu; one on each telofemur; one on each basifemur; and a short curved clavate seta on each trochanter. Each tibia and genu has a shorter medio-ventral spine in addition to the two long spines. Median metapodosomal plate usually with eight setae arranged in a 2-3-3 sequence.

[1] Contribution from Missouri Agricultural Experiment Station, Project No. 36 Entomology Museum, Journal Series No. 1851. Approved by Director.

Body stout, broadly subovate, propodosomal plate (Plate II, fig. 5) produced anteriorly concealing gnathosoma except apices of palpi when extended; a pair of clavate setae on tubercles recessed into margin near apex situated one on either side of median extension of plate; a second submarginal pair midway between anterior pair of setae and anterior margin of coxae I as seen from above; three pairs of postero-lateral setae, the basal pair almost opposite eyes, rarely with an extra pair of setae caudad of third pair. Median metapodosomal plate longer than wide, irregularly rectangular, widest at base, bearing one pair of anterior submedian setae separated from one another by almost three times their length and from anterior margin of plate by less than their own length; three central setae arranged in a subequilateral triangle pointing cephalad, setae separated by little more than their length, median seta absent in about 30% of the specimens (in one specimen an extra median seta occurs about as far caudad as the anterior one is cephalad of the lateral setae); and three basal setae forming

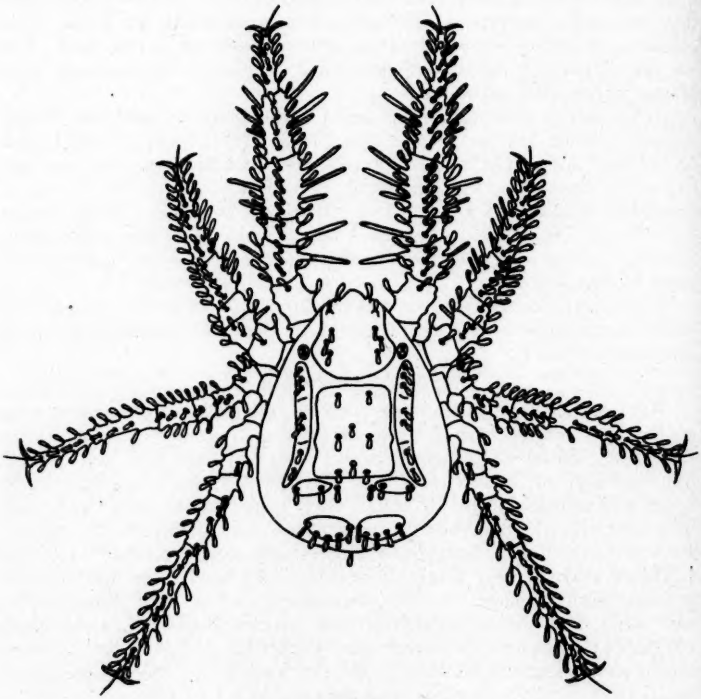

PLATE I
Caeculus cremnicolus, n. sp. Dorsal aspect, adult male.

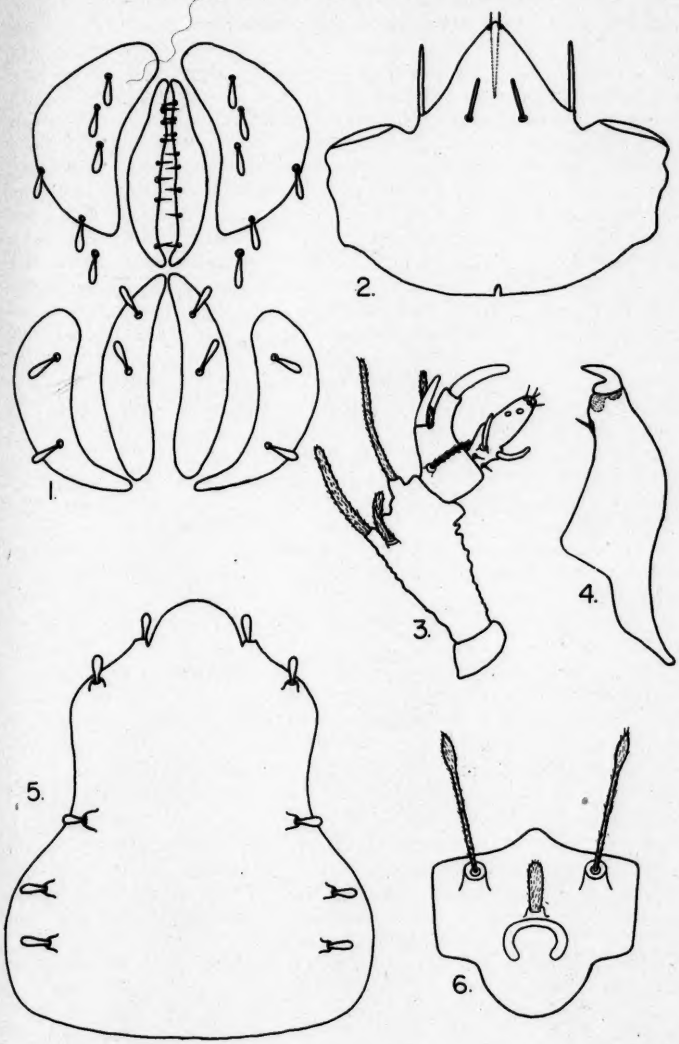

PLATE II

Caeculus cremnicolus, n. sp. Fig. 1, ventral plates. Fig. 2, hypostome. Fig. 3, palpus. Fig. 4, chelicera. Fig. 5, propodosomal plate. Fig. 6, epistome.

a broad shallow triangle, median seta placed cephalad from the lateral setae by scarcely more than width of its tubercle, lateral setae separated by about four times their length and separated from basal margin of plate by half their lengths. Lateral metapodosomal plates each with six or seven setae arranged in a 3-2-2 or 3-2-1 (rarely 2-2-2) sequence, posterior seta usually about in line with basal setae on median plate; two more or less transverse stigmal openings in each plate, one at anterior third and one at basal third. Eyes large, prominent, situated almost directly above fused margins of coxae I and II and mesad about twice their width from lateral margins of body. Anterior opisthosomal plate with two heavily sclerotized, transversely oval areas, one on either side of median area which is broader than either sclerotized area, six setae usually present in an irregular transverse row arranged two setae on each sclerotized area and one pair submedially between sclerotized areas but total number varying from five to seven. Posterior opisthosomal plate with two heavily sclerotized transverse areas similar to preceding, one on either side, each larger than those on anterior plate and each usually furnished with four setae with one additional pair of submedian setae placed between the areas; and one single seta medially at extreme apex of opisthosoma.

Epistome (Plate II, fig. 6) with one pair of widely separated dorsolateral sensillae which are feebly enlarged distally, set in prominent tubercles; a single short stout dorso-median seta on a tubercle posterior to dorso-lateral sensillae. Chelicerae (Plate II, fig. 4) stout, compressed, widest at middle, armed distally with a sharp curved bladelike claw, base of claw subacutely rounded, a minute spine below base of claw. Hypostome (Plate II, fig. 2) with one pair of submedian spines flanked on either side by a long slender seta, these four structures arranged in a transverse arc across hypostome ventrally.

Palpi (Plate II, fig. 3) with coxae fused at bases; trochanters short, unarmed; femora long, each with three long setae on tubercles distally; tibiae each with a long spinelike claw at apex, a similar shorter one subapically, and two long straight setae set on tubercles medially; tarsi short, obliquely inserted on basal halves of tibiae, each armed with a circle of four short spines at base and apex and with three spinelike setae on short tubercles circling tarsus medially.

Genital orifice (Plate II, fig. 1) elongate bordered by moderately wide, arcuate, heavily sclerotized plates, each plate usually with seven slender acute spines arranged in a longitudinal row, inclined mesad, posterior pair of spines somewhat more distant from the next than remaining spines from each other; a broad subcrescentic sclerotized plate laterad of border plates in males, considerably reduced in females, separated from genital border plates by about width of each border plate, each lateral plate with five clavate setae arranged three in a curve on inner margin, fourth seta submedially at posterior border and fifth near extreme lateral margin approximately one third the distance from base to apex, a clavate seta arising immediately caudad of each lateral plate. Anal orifice (Plate II, fig. 1) longer than genital, bordered by sclerotized arcuate plates which are broader than those bordering genital opening, each bearing two clavate setae, anterior seta

arising medially about one sixth the distance from apex to base, posterior seta almost at center of plate. A subcrescentic sclerotized plate laterad of each border, each about as wide as border plate and separated from it by about its width, some specimens with lateral plates much reduced, each lateral plate bearing two setae, anterior seta at apical fourth medially, posterior seta at caudal third medially. A single clavate seta arising from a tubercle posterior to each lateral plate near apical margin of opisthosoma.

Legs I from bases of trochanters to apices of tarsi distinctly longer than body, each with two rows of long straight spines set on tubercles, one row on medio-ventral margin, the other on outer ventral margin. Setae and spines arranged as follows: coxae I each with four setae on tubercles on median line and an additional one at extreme base; trochanters I each with two short, curved clavate setae on tubercles, one situated on mesal margin midway between base and apex, and one medially at apical dorsal margin, setae scarcely longer than their tubercles; basifemora I each with ten setae usually arranged with four short setae and one long one on outer margin ventrally, two short setae on inner ventral margin, a long mesal seta on a long tubercle (the seta straight, parallel-sided, twice as long as its tubercle, blunt at apex), and three dorso-median setae; telofemora I each with seven setae arranged with two short curved setae and one long straight one on mesal margin, the latter similar to that on basifemora, two short curved setae dorso-medially, and two similar ones on outer margin; each genu with twenty setae arranged with two long setae, another about half as long, and five short curved setae on mesal margin; one long, one half as long, and five short curved setae on outer margin, and five short curved setae dorsally on median line; tibiae I each with twenty setae arranged with two long, one half as long, and five clavate setae irregularly spaced on mesal margin; two long, one half as long, and four clavate setae on outer margin; and four setae dorsally on median line; tarsi I each with fourteen or fifteen setae arranged with four short clavate setae on mesal margin and four similar ones on outer margin with six short acute setae in two rows ventrally, and an irregular number dorsomedially; a dorsal sensory pit medially at apical fifth, and a long slender dorsal seta arising from a tubercle just below apex. Claws on all tarsi two in number, dissimilar in size in some specimens, moderately large, curved, acute at apices.

Coxae II each with a single seta on a tubercle at basal fourth. Coxae III each with two similar setae, one near base, the second at about basal fourth, and usually one or two additional small setae spaced between the latter seta and apex of coxa. Coxae IV with three setae on tubercles, basal one at proximal fifth, apical one at distal third, the central one between but nearer basal seta. One or more pairs of setae on ventral area between right and left coxae IV. A transverse row of six setae on tubercles arranged in an arc posterior to coxae IV and anterior to genital plate.

Trochanters II each with one short curved seta on a tubercle on anterior margin, one dorso-medially, and one on posterior margin. Trochanters III each usually with three clavate setae anteriorly, median seta obscured by other two in some specimens, and one seta dorso-medially. Trochanters IV

each with one or two short curved setae on tubercles on antero-ventral margin.

Remainder of leg segments as illustrated in Plate I. All tarsi with a long slender tactile seta arising at about apical fourth of each.

NYMPHS. A number of specimens apparently in the ultimate nymphal stage were taken in association with adults. They are quite similar to the adults but are smaller in size, ranging from 1.2 mm. to 1.4 mm. in length (average 1.28 mm.) and 0.8 to 0.9 mm. in width (average 0.84 mm.). In addition they have much less heavily sclerotized plates and the genital border plates usually have only three pairs of setae. Some variation occurs but usually there are three setae on the left border and three to five on the right border. All legs are seven-segmented.

Types: The holotype (female) and allotype will be deposited in the U.S. National Museum. Paratypes will be deposited in the following institutions: American Museum of Natural History; Museum of Comparative Zoology, Harvard University; University of Utah; University of Kansas; University of Missouri; and the U.S. National Museum. The slides are labeled: 2 mi. NW of Wilton, Mo., XII-4-1954, Limestone bluff, No. 12454-1, various collectors' names including Dan Stout, M. C. Grabau, P. J. Spangler, and W. R. Enns.

Additional specimens, not included in the type series, were taken by P. J. Spangler and M. C. Grabau on December 23, 1954, at Easley, Missouri, some six miles upstream from the Wilton location but in a similar environment. On May 17, 1956, specimens were also taken at Devils Backbone near Englewood, Missouri.

This species is morphologically similar to *C. archeri* Mulaik and *C. pettiti* Nevin. It is readily distinguishable from the former by its larger average size, form of propodosomal plate as well as larger number of setae on that plate, large number of setae on median and lateral metapodosomal plates, and greater number of setae on posterior opisthosomal plate. From the latter it is easily separable by its larger size, greater number of setae on propodosomal plate, single median seta on epistome, smaller number of setae on anterior and greater number on posterior opisthosomal plates, setae on plates laterad of genital opening, and arrangement of setae on the coxae.

The mites taken by us must have fed recently because large quantities of unidentifiable material had to be pressed out of the body before clearing could be complete. Included in the contents were bright orange globular objects which may have been eggs but, if so, it was not apparent whether of the mites or of their prey. The specimens were covered with a tenacious coating of transparent material to which particles of dirt adhere strongly. Treating a few specimens in potassium hydroxide proved to be disastrous to setae and spines. Most of the remainder were cleared in lacto-phenol and embedded in Hoyer's medium.

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TWO NEW GENERA OF GERRIDAE WITH THE DESCRIPTION OF A NEW SPECIES

HERBERT B. HUNGERFORD AND RYUICHI MATSUDA[1]

In our study of the *Tenagogonus-Limnometra* complex we discovered that the five species of the Western Hemisphere assigned to *Tenagogonus* are not congeneric with either *Tenagogonus* Stål, 1855, or *Limnometra* Mayr, 1865. The senior author in a paper given at the International Congress of Entomology in Montreal in August, 1956, reported this fact and stated that these New World forms would be given a new generic name. We submitted this paper for publication in April, 1957. However, before it appeared, Dr. C. J. Drake (October 4, 1957) proposed the new genus name *Tachyognus* for these insects and since this name was preoccupied he proposed (December 31, 1957) the name *Tachygerris* with *T. adamsoni* (Drake) as the type species. Since he gave neither drawings nor description of *Tachygerris* we are simply substituting *Tachygerris* Drake for the name we were proposing and accepting *T. adamsoni* (Drake) as the type of the genus instead of *Limnometra quadrilineata* Champion, a better known species.

Tachygerris Drake

Tachygonus Drake, C. J. Proc. Biol. Soc. Washington, 70:111, 1957.
Tachygerris Drake, C. J. Proc. Biol. Soc. Washington, 70:193, 1957.
Type species of the genus: *Tachygerris adamsoni* Drake.

Rather slender, macropterous gerrids with short golden hairs on the hemelytra, which have the veins R and M separating some distance beyond their junction with subcosta 2.[2]

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[1] Contribution No. 969, Department of Entomology, University of Kansas. This study was made possible with the aid of a grant from the National Science Foundation.

[2] We can find no precedent for naming the vein we are calling subcosta 2. It is shown but not named by Tanaka and Hoke. Its direction makes it unlikely that it is R_1. Unfortunately also the axillary sclerites of the adult gerrids do not connect with the bases of the veins to give us clues to the correct naming of the veins. The names we have used therefore must be tentative. Reference to the above mentioned papers are as follows: Tanaka, T. 1926. Homologies of the wing veins of the Hemiptera. Annot. Zool. Tokyo, Japan. 2:33-53. Hoke, S. 1926. Preliminary paper on the wing venation of the Hemiptera. Ann. Ent. Soc. Amer. 19:13-34.

The pronotum is marked by a median pale line on the anterior lobe, and the anterior lobe, meso- and metaacetabula are clothed with conspicuous silvery sericeous spots above. The omphalium is reduced, on a longitudinal keel, and is nearly one third the length of the metasternum from its posterior margin. The abdominal spiracles are located midway between margins of each segment. The last ventral abdominal segment of the female is longer than any preceding segment. The antennae are long and slender, as long as the body in some species; the first segment is slightly curved, a little stouter and longer than the second segment, and is not as long as the fourth which is the longest. The beak is slender, reaching nearly one half the length of the mesosternum. The front femora are slender, plainly curved in the male, slightly curved in the female, a little stouter than the middle femora; the front tarsal segments are subequal; the middle and hind legs are moderately long, the middle femur is not as long as the body.

This new genus can easily be distinguished from *Tenagogonus* and *Limnometra* by the distinct wing venation, golden short hairs scattered in basal half of the hemelytra, and by the location and higher degree of reduction of the omphalium. Thus far no apterous forms are known in this genus although rarely brachypterous forms with complete wing venations occur.

It includes the five species which were keyed out by Louis Kuitert under the genus *Tenagogonus* in 1942 [Univ. of Kansas Science Bulletin vol. 28(7):131-132], namely *Tachygerris quadrilineatus* (Champ.), *T. celocis* (D. and H.), *T. spinulatus* (Kuitert), *T. opacus* (Champ.), *T. duolineatus* (Kuitert) which Drake says is a synonym of *T. adamsoni* (Drake), and a new one represented by a single female specimen from "Suriname."

Tachygerris surinamensis n. sp.
(Pl. I, C; Pl. II, C, D)

Size: Winged female holotype, length 6.7 mm.; width across mesoacetabula 2.0 mm.; width across head 1.3 mm.

Color: Pale brownish above, with pattern of darker lines very faint; the hemelytra a little darker; general appearance as in *L. celocis* (D. and H.) and *L. opacus* (Champ.).

Structural characteristics: The relative lengths of antennal segments: 1st:2nd:3rd:4th are 57:40:73:130. The relative length of the total length of the antenna to the body is 6.3 mm.:6.7 mm. The relative lengths of the front leg segments:femur:tibia:1st tarsal:2nd tarsal are 100:80:17:16; the middle femur is 235, other segments are gone; the hind femur is 223, other segments are gone. The antennae are slender, and the third and fourth segments are the longest. The terminal connexival spines are short. The last pregenital ventral abdominal segment (7th segment) with three projecting angles on its caudal margin is as shown in Pl. II, C.

Comparative notes: Known only by the female holotype. A comparison of figure C of plate II with the figures on plate X of Kuitert's paper will identify this species. As in *T. opacus* (Champ.), *T. celocis* (D. and H.) and and *T. spinulatus* (Kuitert) the third antennal segment is plainly longer than the first. Its nearest relative appears to be *T. opacus* (Champ.)

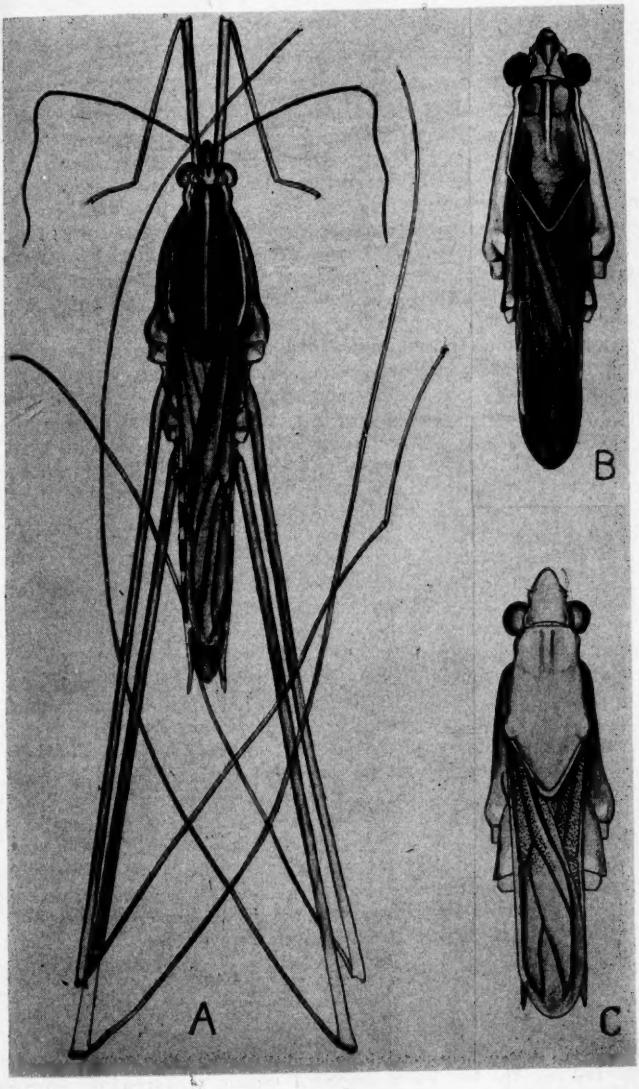

PLATE I

A. *Gigantometra gigas* (China). B. *Tachygerris duolineatus* (Kuitert). C. *Tachygerris surinamensis* Hungerford and Matsuda.

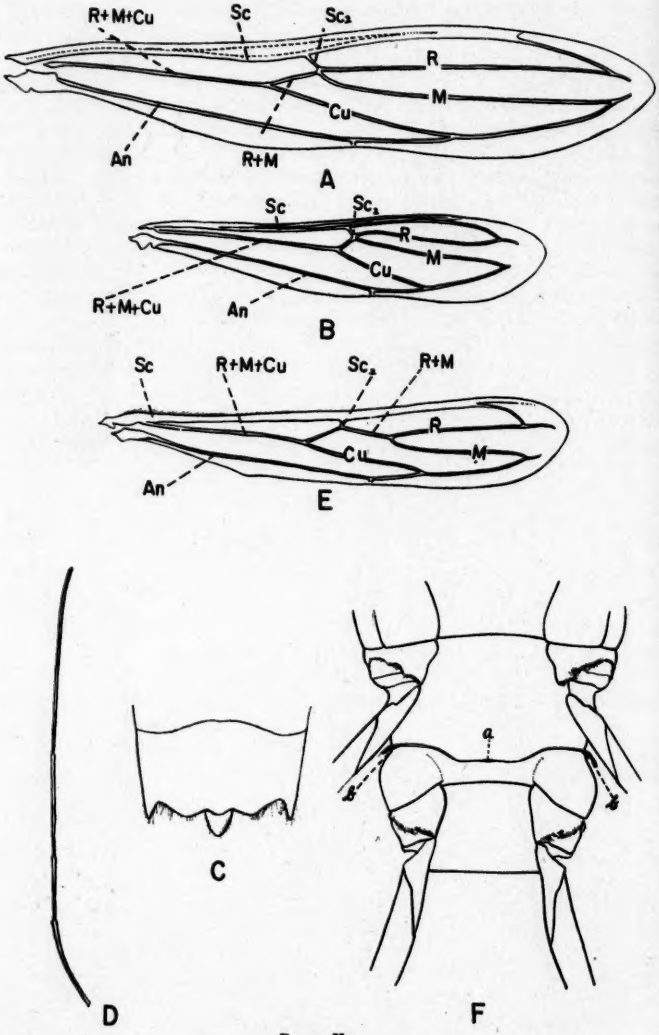

PLATE II

A. The forewing of *Limnometra ciliata* Mayr. B. The forewing of *Tenagogonus albovittatus* Stål. C. The last ventral abdominal segment of *Tachygerris surinamensis* Hungerford and Matsuda. D. The antenna of *Tachygerris surinamensis* Hungerford and Matsuda. E. The forewing of *Tachygerris quadrilineatus* (Champion). F. The meso- and metasterna of *Gigantometra gigas* (China) showing the omphalium at *a* and the scent gland channels leading to lateral orifices that are guarded by hair tufts at *b*.

Gigantometra n. gen.
Type species of the genus: *Limnometra gigas* China 1925
(Pl. I, A; Pl. II, F)

This new genus is proposed for the above species because it possesses a reduced omphalium with lateral channels that lead to raised scent gland openings guarded by hairs in front of the metaacetabula. This is a character we have found to be of generic significance. The antennae are shorter than the body, about 22 mm. long compared to 35 mm. for the body. The middle and hind femora are much longer than the body, and the hind legs, because of the unusual length of the tibiae, are considerably longer than the middle legs. The hemelytra have a wing venation like *Limnometra*. The abdominal spiracles are closer to the anterior than to the posterior margin of each segment as in *Limnometra*. No *Tenagogonus* or *Limnometra* has the hind legs longest nor do they possess lateral scent gland openings connected to the omphalium. The pale longitudinal pronotal line sets this species apart from any *Limnometra* or *Tenagogonus* species of the Far East for they all have a black line. In this respect it is like *Tenagogonus longicornis* Poisson from Africa with which it is not congeneric.

Dr. China placed this gigantic gerrid, which dwarfs all others, in *Limnometra* Mayr. His specimen is a male from "Tonkin, Thai-Nien, basin of Fleuve Rouge 1924." It is 34 mm. long. We have before us a male from "Ta Han, Hainan Island" that is 35 mm. long and has middle femora that are 50 mm. long. Since it is from across the Gulf of Tonkin from where Dr. China's specimen was taken and fits his description we believe it to be the same species. We were impressed at once by the omphalium and its lateral channels that lead to lateral scent gland openings. Dr. China kindly reexamined the type for us and wrote "We have examined the type specimen of *Limnometra gigas* and found that it possesses the lateral tufts of hairs at the end of what appears to be scent gland channels leading from the omphalium although the connection between the latter and the hind acetabula is extremely indistinct." In our specimen it is very distinct. Since the hind tarsus is missing on the type we give the length of the segments of the hind legs in the specimen before us: femur, 48 mm., tibia 75 mm., 1st tarsal segment 2.95 mm., 2nd tarsal segment .84 mm. We have found that there is considerable variation in the proportions of the leg segments and the antennae in *Limnometra*-like gerrids. Moreover, there may be considerable sexual dimorphism; for example, we have two males of *T. longicornis* Poisson in which the first segment of the antenna is nearly as long as the insect and two females with the first segment not reaching the humeri. Such problems have challenged us to find characters that have stability at least at the generic level.

THE ALIMENTARY CANAL OF THE ADULT OF *TRIBOLIUM CASTANEUM* HERBST (Coleoptera, Tenebrionidae)[1]

R. N. SINHA[2]

The red flour beetle, *Tribolium castaneum* Herbst is a common pest of stored grains throughout the world. It infests a wide variety of dried products, including all kinds of grains, flour, starchy materials, beans, peas, baking powder, ginger, dried plant roots, dried fruits, insect collections, nuts, chocolate, drugs, cayenne pepper, etc. (Metcalf and Flint, 1951). The adult insect is about 5 mm. long, flattened and reddish brown in color.

A considerable amount of work has been done on the ecology, biology and physiology of *Tribolium castaneum*. But any detailed work on the internal anatomy is lacking. Thus the purpose of this study is to describe the detailed anatomical and cellular structures of the fully grown adults of the species. This paper concerns the alimentary canal. The descriptions of other organs will be published later. A part of this study was done in 1951-1952 at the Entomology Laboratory, Department of Zoology, University of Calcutta.

MATERIALS AND METHOD

Hundreds of live adult specimens of *Tribolium castaneum* Herbst were collected from storehouses and granaries and raised in the laboratory in Calcutta. These insects were used for dissection and sectioning. The insects were reared in different food media to study the effect of food on the life history of the beetle (Mukerji and Sinha, 1953) as well as the internal anatomy and histology. The adult beetles used for this study were reared in wheat flour. Approximately one hundred dissections were made with a fine pointed needle under a binocular microscope. The process was as follows: Specimens were chloroformed, the elytra removed, and then the body was cut open from the dorsal side. Each dissection was made on a slide with the insect submerged in a drop of 0.5% saline solution. For histological study approximately sixty adult insects were prepared in the following way: The live insect was fixed in Mukerji's fixative (Mukerji, 1937) for six days and then embedded in celloidin and paraffin successively. Serial sections of the entire body, 6 to 8 μ in thickness, were made in transverse and longitudinal planes. The technique used for sectioning the sclerotized beetles was that of Mukerji with the author's modifications (Sinha, 1953). Some dissections of the alimentary canal were also made in 0.5% saline solution, fixed in Carnoy and Lebruns' fluid (Lee, 1937) for 24 to 48 hours, lightly stained in eosin (to avoid confusion with white paraffin), and sectioned by the ordinary paraffin method. Sets of the serial sections of the insects were stained in Mallory's triple stain, picro-indigo carmine (Lee, 1937), and Delafield's hematoxylin and eosin.

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Prepared slides were studied under an oil immersion lens and also with a phase-contrast microscope to discern the details of the cellular structures.

GROSS ANATOMY OF THE ALIMENTARY CANAL

GENERAL DESCRIPTION. The alimentary canal of *Tribolium castaneum* is a straight tube (except the two simple loops in the hindgut) of approximately 5.5 mm. length. On the basis of cellular structure it is divided into three main regions, the anterior foregut (stomodaeum); the middle portion, midgut (mesenteron or ventriculus); and the posterior portion, hindgut (proctodaeum). The foregut and the hindgut, as in other insects, are continuations of the body wall and probably ectodermal in embryonic origin, whereas the midgut is more likely to be endodermal.

GROSS STRUCTURE OF THE FOREGUT. The foregut is rather short, measuring from 0.71 to 1 mm., that is, about one-fifth as long as the alimentary canal. It is relatively long when compared with other tenebrionid species studied by authors (Miller, 1931; Auten, 1933). Starting at the anterior end it begins with a buccal cavity, followed by pharynx, oesophagus, crop, proventriculus and the oesophageal invagination.

The oesophagus is a short uniformly narrow tube with two wide ends; the anterior end is the end of the pharynx, which is a well marked and wide tube, and the posterior end is the beginning of the short and poorly defined crop, which is a slight enlargement of the foregut from the distal end of the oesophagus.

The proventriculus is the widest part of the foregut. It is short and continuous with the preceding crop.

The oesophageal invagination is recognized externally by a weak constriction at the beginning of the circle of papilliform diverticula.

GROSS STRUCTURE OF THE MIDGUT. The midgut or stomach is the widest part of the alimentary canal. It is 1.44 mm. to 2 mm. long and comprises nearly two-fifths of the alimentary canal. This ratio more or less agrees with those of the midguts of Tenebrionid beetles studied by different authors (Miller, 1931; Auten, 1933; Krall and Jones, 1943). It is uniformly wide throughout except for slightly tapering ends and is terminated by the pyloric valve and the malpighian tubules. The entire surface of the midgut is covered by irregularly arranged papilliform diverticula.

GROSS STRUCTURE OF THE HINDGUT. The hindgut or proctodaeum comprises the longest part of the alimentary canal. It is 2.42 mm. to 2.57 mm. long, that is, comprising nearly one-half the length of the entire alimentary canal. Almost similar ratios of the hindgut have been found in *Bolitotherus cornutus* studied by Auten (1933), and *Meracantha contracta* Beauv. studied by Miller (1931). The hindgut is subdivided into the pylorus, the ileum or small intestine, the colon or large intestine, and the rectum.

The pylorus is located at the junction of the midgut and the hindgut. It is recognized by a constriction at the region of the midgut where papilliform diverticula abruptly end and malpighian tubules are attached by their proximal ends.

In agreement with other studied forms in the family Tenebrionidae, six malpighian tubules are found arising from the junction of the ileum and

the midgut. Each tubule first extends cephalad in the body cavity up to the level of the anterior end of the midgut where it forms a loop and runs posteriorly in a wavy course through the fat bodies till it reaches the rectum. Here it lies against the outer wall of the hindgut.

The ileum is a narrow U-shaped tube between the pylorus and the colon.

The colon is not well defined. The gradually widened posterior portion of the ileum may be called the colon.

The rectum is composed of two parts, the anterior spindle-shaped wide tube or the rectal sac and the narrow funnel-shaped posterior tube or rectum proper. The rectum proper opens to the exterior of the body through the anus.

HISTOLOGICAL STRUCTURE OF THE ALIMENTARY CANAL

FOREGUT. The cellular layers of the foregut are arranged in the following sequence from the lumen outwards: (1) a chitinous inner lining, the intima; (2) an epithelium of epidermal cells; (3) a basement membrane; (4) a layer of longitudinal muscles; (5) a layer of circular muscles; and (6) a peritoneal membrane or a layer of connective tissue. This sequence is found in all the subdivisions of the foregut even though the modification of a layer or layers is characteristic of particular subdivisions.

The noncellular intima is homologous to the external body wall or cuticle. This layer is probably secreted by the epidermal cells. The intima is thick and bears hairs in the pharynx and the proventriculus. Hairs in the pharynx are short, dense and arranged in tufts. Hairs in the proventriculus (Plate I, figure 2) are thick, long, sparse and localized on and around the proventricular folds. Hairs in both regions are usually directed posteriorly except those on the dorsal side of the pharynx which are directed anteriorly. The ridges of thick intima covering the proventricular pads are probably for grinding particles of food, and the hairs perhaps sieve the particles of food of different size and also prevent the food from being forced cephalad during the process of grinding. Similar explanations are suggested by other authors (Snodgrass, 1935; Bess, 1935).

The epithelium is made up of cuboid cells. These cells become flattened and elongated when a particular area of the foregut is filled with food.

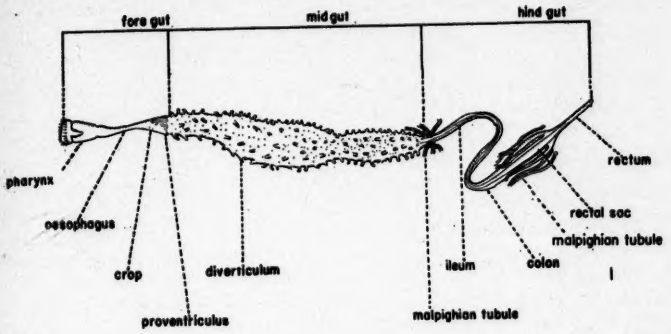
The basement membrane supporting the epithelium is extremely thin and was observed in places along the foregut.

The longitudinal muscles are well defined around the pharynx but are sparsely distributed along the oesophagus and the anterior part of the crop. Longitudinal muscles are most prominent and form a layer three to four strands thick along the posterior part of the crop and the proventriculus.

A continuous layer of circular muscles (one strand thick) surrounds the longitudinal muscles and forms a complete outer layer. The other layers, the intima, the epithelium and the longitudinal muscles together form longitudinal folds which are irregular and variable in number along the oesophagus and the crop. In the proventriculus they are regularly arranged in eight distinct folds. The surface of the folds comprises approximately one-third the lining of the proventriculus. A ring of circular muscles surrounds the area of proventricular pads.

The peritoneal membrane or the outermost layer of connective tissue surrounds the circular muscles. This was visible only in certain sections. It is probably due to technical difficulties that in particular places it was not preserved.

The oesophageal invagination is a large fold of the posterior end of the foregut extending into the lumen of the midgut. Therefore, the structure of the invagination is similar to the wall of the proventriculus. The intima



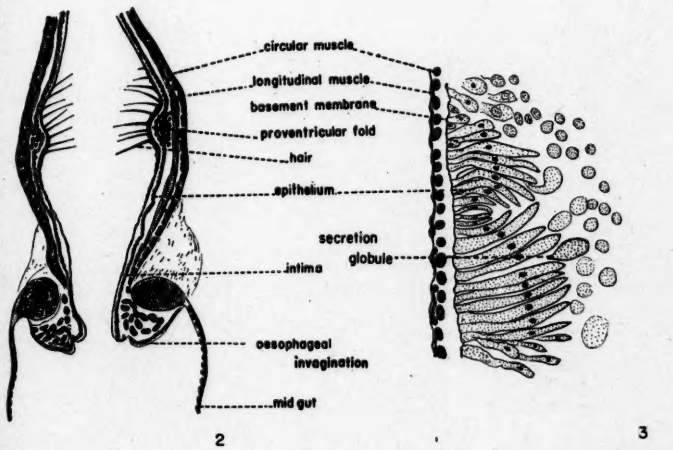


PLATE I

Tribolium castaneum Herbst. Fig. 1. Alimentary canal. Fig. 2. Longitudinal section of proventriculus X 133. Fig. 3. Longitudinal section of a portion of midgut, X 133.

is thin and disappears on the outer surface of the fold. The epithelial cells of the fold are similar to those of the wall of the proventriculus. Longitudinal muscles are absent in this region, but circular muscles increase greatly in number of strands and are aggregated inside the fold probably to serve as a sphincter at the opening of the midgut. The oesophageal invagination probably regulates the entry of food materials into the midgut and conducts food well into the midgut.

MIDGUT. The sequence of layers of cells of the midgut is as follows, beginning with the inner lining of the digestive cavity outwards: (1) epithelium, (2) basement membrane, (3) circular muscles, (4) longitudinal muscles, (5) connective tissue.

The epithelium is composed of large, elongated columnar cells. The free ends of the cells may have extremely thin striated borders which have not been illustrated in Figures 3, 4 and 8. Cells are generally larger in the anterior region of the midgut than in the posterior region. There is a large rounded nucleus near the middle of each cell. The wall of the midgut is evaginated to form diverticula which also contain columnar cells continued from the epithelium of the midgut. The regenerative cells or nidi occur at the apical area of the diverticulum and from there replace the new cells for the interdiverticular epithelium as the old ones degenerate. This arrangement of the regenerative cells is common among some Coleoptera (Day and Waterhouse in Roeder, 1953:277).

The basement membrane is rather thick and conspicuous throughout the length of the midgut.

The layer of circular muscles varies from one to two strands in thickness in different parts of the midgut.

The longitudinal muscles are irregularly distributed as single isolated strands outside the circular muscles.

A moderately distinct layer of connective tissue surrounds the midgut as the outermost cellular covering.

No evidence of a peritrophic membrane was found. This is significant because such a membrane has been observed in another well studied Tenebrionid (*Meracantha contracta,* Miller, 1931).

HINDGUT. Histologically the hindgut consists of the following layers, from the lining of the digestive cavity outwards: (1) intima, (2) epithelium, (3) basement membrane, (4) longitudinal muscles, (5) circular muscles, and (6) connective tissue.

The pyloric valve is formed by a layer of highly specialized epithelial cells at the cephalic end of the hindgut. These cells are more elongated than those in other parts of the hindgut and are arranged in a semicircular pattern in longitudinal section (Plate II, figure 8). A group of four or five scattered circular muscles is enclosed within the fold of epithelial cells. The thin intima is curved to form two lateral pockets at the distal end of the valve and then runs straight posteriorly in the ileum. There is a layer of longitudinal muscles (three to five strands in thickness) covering the inner circular muscles. Exterior to the longitudinal muscles there is a layer of outer circular muscles. This layer is large and one strand in thickness. Finally, there is a thin layer of connective tissue.

Malpighian tubules are composed of huge cells with large, rounded or oval nuclei. When viewed in cross-section each tubule consists of two or three large cells (often with indistinct cell walls) surrounded by a thin

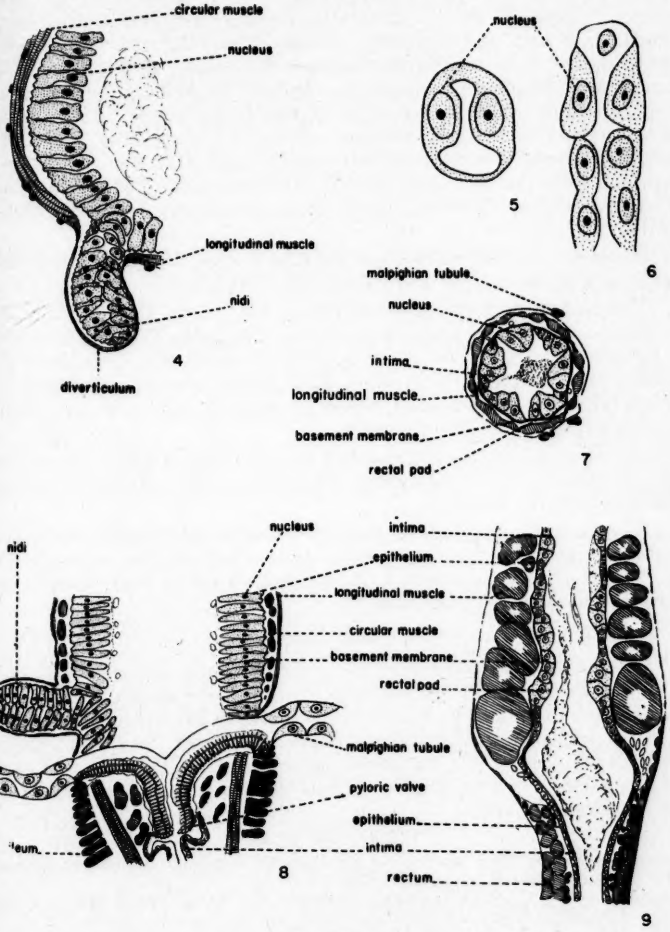


PLATE II

Tribolium castaneum Herbst. Fig. 4. Transverse section of a portion of midgut and longitudinal section of a diverticulum of midgut, × 133. Fig. 5. Transverse section of Malpighian tubule, × 300. Fig. 6. Longitudinal section of a portion of malpighian tubule near the tip, × 300. Fig. 7. Transverse section of rectal sac, × 133. Fig. 8. Longitudinal section at the junction of midgut and hindgut, × 133. Fig. 9. Longitudinal section of rectal sac and rectum proper, × 266.

layer of connective tissue (Plate II, figures 5 and 6). No ciliated border on these cells was detected. The lumen of the tubule is somewhat narrow. Malpighian tubules can be classified under "cryptonephridic" or the second type (out of a total of four types) of Malpighian tubules discussed by recent authors (Patton in Roeder, 1953:391; Wigglesworth, 1953:369). When viewed in a series of longitudinal sections of the entire insect body, the distal parts of these tubules lie closely on the surface of the rectum. Although no enveloping membrane was detected for holding the tubules in place, the extremely close position of the two organs justifies the use of the term "cryptonephridic." In addition, similar arrangement of Malpighian tubules has been recorded in different families of Coleoptera, including the members of the family Tenebrionidae (*Tenebrio molitor,* Patton and Craig, 1939; *Bolitotherus cornutus,* Auten, 1933; *Meracantha contracta,* Miller, 1931).

ILEUM, COLON, RECTAL SAC AND RECTUM PROPER. The intima is distinct in all parts of the hindgut. It is thickest in the rectal sac.

The epithelium is composed of cuboid cells which are smaller in the ileum and rectum and larger in the colon. The epithelium is thrown into a number of irregular folds. These folds are continuous throughout the colon and in the rectal sac in which six regularly arranged rectal pads are found. The same number of rectal pads has been observed in all other forms studied in the family Tenebrionidae.

The layer of circular muscles is one strand in thickness in the ileum and two to four strands in thickness in the rectum proper. It is absent in the colon and the rectal sac.

The layer of longitudinal muscles is composed of stout individual muscles arranged in a zigzag pattern in the colon and the rectal sac. The rest of the hindgut is provided with a somewhat thin layer (usually one strand in thickness) of such muscles.

ACKNOWLEDGMENT

The author wishes to express his appreciation to Professor D. Mukerji, Head of the Department of Zoology, University of Calcutta, for his guidance during the laboratory studies of this work; to Dr. K. Doering, Department of Entomology, University of Kansas, Lawrence, for helpful suggestions and criticism of the manuscript, and to Mr. J. G. T. Chilcott, Division of Entomology, Science Service, Canada, for his criticism of some of the interpretations of slides.

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REMARKS ON THE GENUS *ZERCON* C. L. KOCH, WITH DESCRIPTIONS OF TWO NEW SPECIES OF THE GENUS *PROZERCON* SELLNICK (ACARINA, ZERCONIDAE)

MAX SELLNICK
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While studying in 1939 the acarofauna in the area around Regensburg, Bayern, Germany, where Koch collected his mites more than a hundred years ago, I rediscovered all his species which belong to the genus *Zercon* s. str.

I stated (Sellnick, 1944) that *Z. dimidiatus* C. L. Koch 1839 and *Z. triangularis* C. L. Koch 1836 are the same species, *Z. dimidiatus* being the male, *Z. triangularis* the female. Therefore the genus *Triangulozercon* Jacot 1938 is superfluous. It is very difficult for a scientist of a foreign nation to understand Koch's expressions in the short descriptions of his species. After fifty year's study I believe that I understand his terms and therefore I believe that my interpretations concerning the genus *Zercon* are correct.

Z. triangularis having been published 3 years before *Z. dimidiatus,* I propose to settle the genus in the following manner:

Zercon C. L. Koch 1836. D.C.M.A. 4:15. Type species: *Zercon dimidiatus* C. L. Koch 1839. D.C.M.A. 38:17 (♂) [=*Zercon triangularis* C. L. Koch 1836. D.C.M.A. 4:16 (♀)].

Willmann (1943:211) has published my genus *Prozercon* under my name. Therefore we must write:

Prozercon Sellnick 1943, in Willmann, Arch. F. Hydrobiol. 40:211.

Type species: *Zercon fimbriatus* C. L. Koch 1839. D.C.M.A. 27:7.

In my key to the genera of the Zerconidae published in 1944 I have indicated several characters for the three genera mentioned there. But only one of these characters may be noted as being constant within each genus. That is the hairs on the anterior part of the peritremal plate. *Prozercon* Sellnick always has two little bristles on this shield, *Zercon* C. L. Koch a large hair and a little bristle, *Parazercon* Trägårdh a large hair and two bristles.

Mr. Neil A. Walker, University of California, Berkeley, was kind enough to send me some collections containing a number of Zerconidae. Among them I discovered two new species of the genus *Prozercon* Sellnick.

Prozercon californicus n. sp.

Female: length 305 μ, width 255 μ. Male: length 270 μ, width 210 μ. Color reddish yellow-brown.

Texture of notocephale (anterior shield of dorsum) an irregular network of lines, composed of little knobs in the anterior part and wavy lines in the middle of the plate. The posterior part of the shield has only a few lines and points.

The posterior plate of the dorsum, the notogaster, ascends gradually from the posterior border of the notocephale to the highest point of the body, nearly lying above the anal opening, and then slopes steeply down to the posterior border of the body. The middle of the ascending part is a broadly rounded hill, the lateral borders of which slope gently down to the lateral borders of the body, forming a hollow of moderate depth on each side of the hill.

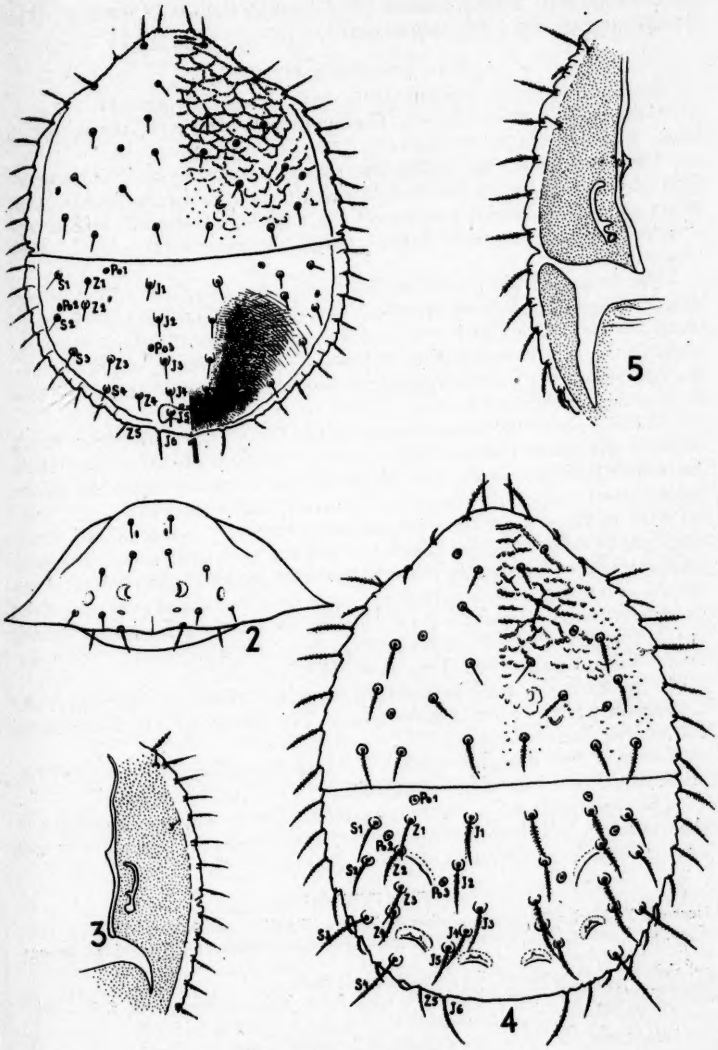
The dorsal view shows a strange chitinization at the posterior end of the hill, somewhat similar to a dumbbell, in fig. 1 marked as a dotted area. But regarded from the posterior end of the body (fig. 2), we see two little hollows formed like half-balls, 36-40 μ distant from each other, their openings directed toward each other. Probably there is a low indentation going from one hollow to the other, the overhanging border of which differentiates the handle of the dumbbell. The two hollows are the inner two of the four holes, situated parallel to the posterior border of the body, characteristic of the Zerconidae s. str. The outer ones are faint impressions, 32 μ distant from the inner ones (fig. 2).

All the hairs on the border of the body are barbed. There are three rows of hairs on the notogastral plate of all Zerconidae. The inner row is denoted by the letter J (fig. 1). J:1 to J:5 are smooth, J:6 barbed. The intermediate row is called Z:1 to Z:5. Only Z:5 is barbed. The lateral row S:1 to S:4 has only smooth hairs which do not reach the border of the body.

The pore Po:3 is situated somewhat outward from a line between J:2-J:3 and somewhat beyond the middle of this distance. This position is unusual, for in European species the pore lies outside Z:3-Z:4.

Fig. 3 is a drawing of the peritremal shield. The anterior part shows the two little bristles characteristic of the genus *Prozercon*. In European species, the peritremal shield continues nearly to the posterior border of the body and there is an interval, between this plate and the ventrianal one, which reaches the posterior border. In *P. californicus,* these two plates are fused and there is only a short pointed notch between the peritremal plate and the anterior lateral border of the ventrianal shield.

In the male, the interval between the peritremal plate and the ventrianal one is perfectly horizontal, of equal width and ends bluntly, half way between the outer border of coxa IV and the outer border of the body. This difference between the sexes is unusual in Zerconidae. The male genital opening is situated exactly between the coxae III.



EXPLANATION OF FIGURES

Prozercon californicus Sellnick, female: fig. 1, dorsal aspect; fig. 2, posterior aspect of body; fig. 3, peritremal plate and part of ventrianal shield. *P. praecipuus* Sellnick, female: fig. 4, dorsal aspect; fig. 5, peritremal plate and part of ventrianal shield.

Locality: Ben Lomond, Santa Cruz County, California, June 21, 1953, on redwood or laurel (C. D. MacNeill).

Prozercon praecipuus n. sp.

Female: length 405 μ, width 330 μ. Male: length 345 μ, width 270 μ.

Color reddish yellow-brown. The notogastral plate especially is covered with dirt.

The notocephale (fig. 4) has rows of small knobs which in the anterior part of the plate form a network of indistinct ridges. In the posterior half there are only lines and pits, except for a hook between z:1 and i:6. All the hairs are conspicuously barbed, except one pair in the middle of the plate (i:5).

The notogaster has no visible lines or pits. But there is a chitinous ridge going obliquely backwards from Z:2 to the pore Po:3, which lies outward from the line J:2-J:3 and somewhat nearer J:2 than J:3. Apparently the ridge is the upper border of a little hole. The four holes, which are situated parallel to the hind margin of the body, have two or three conspicuous little niches at the anterior inner border.

All the hairs of the notogaster are barbed. Remarkable are the bordering hairs of the plate. The first three hairs are directed obliquely backwards, the fourth hair backwards. The following three are shorter than the former ones, curved a little to the border of the body, nearly appressed.

Also in this species, there is a difference between European and American species concerning the peritremal and the ventrianal plates. The peritremal shield ends in a line with the posterior border of coxa IV, as in the species of the genus *Zercon*. Near the outer border of the ventral side of the notogaster there is a narrow plate, tapering toward the posterior end which is fused with the ventrianal plate. Thus there is a wide space between this lateral shield and the ventrianal one (fig. 5).

In the male, the notch between the ventrianal shield and the lateral one is apparently not as wide as in the female. The genital opening lies between the anterior halves of coxae IV.

Locality: Ben Lomond, Santa Cruz County, California, June 21, 1953, on redwood or laurel (C. D. MacNeill).

The type specimens of the two species are in my collection. Paratypes in the collection of Mr. Neil A. Walker, Department of Entomology and Parasitology, University of California, Berkeley.

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OBSERVATIONS ON THE BEHAVIOR OF BRAZILIAN HALICTID BEES II: *PAROXYSTOGLOSSA JOCASTA*[1]

CHARLES D. MICHENER[2] AND RUDOLF B. LANGE[3]

This paper is intended to present information on the biology of an essentially solitary halictine bee, *Paroxystoglossa jocasta* (Schrottky). It is evident that knowledge of such basically solitary forms is a necessary background for an understanding of the semisocial and social relationships which predominate among Halictinae.

NEST LOCATIONS

Nests of this species were found in flat or nearly flat, firm, bare ground. Most of the observations were made at a suburb (Xaxím) of Curitiba, Paraná, Brazil. Some observations were made, however, at Guarapuava, São José dos Pinhais, and Araucaria, all in the state of Paraná. These localities are at an altitude of about 900 meters on the south Brazilian plateau, an area characterized by freezing temperatures in winter. Some further data on the local conditions are given by Michener, Lange, Bigarella, and Salamuni (1958). *Paroxystoglossa jocasta* appears to be found in savanna and grassland regions and not in forests.

The nests are not found in any sort of definite aggregations. Nonetheless, some areas may have rather numerous nests, perhaps one per square meter, while other seemingly similar areas have none.

SEASONAL ACTIVITY

Paroxystoglossa jocasta is one of the earliest spring bees to appear near Curitiba. On August 13, 1955, one of the first warm days of spring, males and females were common on various flowers, but especially those of *Senecio trichocaulon,* a common early spring flower in the grasslands. About half of the females collected on the flowers had pollen in the crop; some had much pollen among the scopal hairs and were presumably collecting it for provisioning nests, for some complete pollen balls were found in nests on August 15.

To shed some light on the condition of females at this season, the following data were gathered, using methods indicated by Michener, Cross,

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[1] Part I on *Pseudagapostemon,* Ann. Ent. Soc. Amer. 51:155-164. The preparation of this paper was facilitated by a grant from the National Science Foundation. Thanks are due to Father J. S. Moure for identification of the bee, and especially for making all the photographs used in this paper.

[2] Department of Entomology, University of Kansas, Lawrence, Kansas, U.S.A. Field work for this author's part in the study was possible thanks to a John Simon Guggenheim Memorial Foundation Fellowship and aid kindly made available by the Campanha Nacional de Aperfeiçoamento de Pessoal de Nível Superior, Rio de Janeiro; the Conselho Nacional de Pesquisas, Rio de Janeiro; and the Rockefeller Foundation, New York. In particular, thanks are due to Father J. S. Moure for the use of facilities of the Secção de Zoologia, Faculdade de Filosofia, Universidade do Paraná, Curitiba, Paraná, Brazil.

[3] Secção de Zoologia, Museu Paranaense and Faculdade Catolica de Filosofia, Curitiba, Paraná, Brazil.

Daly, Rettenmeyer and Wille (1955): Of thirteen whose spermathecae were examined, twelve had mated and had sperm cells in the spermathecae. Of nineteen whose ovaries were examined, eight had enlarged oocytes (largest over .8 mm. in length), ten had slender ovaries with no oocytes as much as .8 mm. long, and one had slender elongate ovaries, translucent even after fixation, indicating a senile bee that had probably already laid eggs and then survived the winter. Of twenty-seven whose mandibles were studied, thirteen seemed unworn, nine slightly worn, five well worn (none much worn or very much worn). Of twenty-seven whose wing margins were examined, eighteen were unworn, eight were slightly worn (1-4 minute notches broken out of the outer margins of the two forewings), and one was much worn (outer margins of forewings nearly worn away).

From these data it is evident that the females in the population which emerge from hibernation are quite diverse in condition. Most seem to be bees which had not previously done much work but some are obviously worn, a few much so.

Burrows which we excavated on August 13 and 15 were mostly nests of the previous year. Some of them seemed to be abandoned, but in most cases new cells were being constructed or old one relined with wax. Some completely new nests were being dug and consisted only of a burrow with no cells as yet. The most advanced nest was one probably made the season before, in which there were already two completed pollen balls with eggs and a third pollen ball under construction.

Most nests contained only a single female bee although one contained a male as well. Two among ten nests, however, contained two females. One of the two bees in each of these two nests had slender ovaries and seemed fresher (in regard to mandibular and wing wear) than the other. We have no knowledge as to why these bees were together. Perhaps one or both had not left their hibernation quarters or perhaps they would have remained together in these nests. Later in the season we did occasionally find two bees in a nest.

Males were observed on flowers until about September 15. Some twenty-five nests were excavated between August 30 and September 15 (much of the time from August 15 to 30 having been rainy weather). Most of these nests appeared to be newly constructed during the season of observation but a few were probably nests of the preceding season being reused. Two of the twenty-five nests observed during this period contained two females; in both cases the ovaries of both bees showed some enlargement, but those of the bee with the more worn wings and mandibles were larger than those of the less worn bee. Excluding the less worn members of pairs in such nests, the twenty bees collected in nests between August 30 and September 15 showed at least some mandibular wear except for two taken on August 30. The latter had slender ovaries, but all others had at least somewhat enlarged ovaries, the longest oocyte being over .6 mm. long in all cases and over .8 mm. in most. All had mated and had sperm cells in the spermathecae.

After September 15 males were no longer seen. During the second half of September additional nests were seen in very small numbers, compared to hundreds that could be found earlier in the season, and relatively few

females were seen on flowers. However, a few new nests were still being established, as shown by a female with unworn mandibles and wings and slender ovaries found digging a burrow only 3.5 cm. deep on September 26. Similarly fresh looking bees had not been seen since August 30. She had mated although males had not been seen in ten days. Another female in an old (overwintered) burrow had made only a single incomplete pollen ball when the nest was opened on September 26.

During October only three or four more nests were found; most of them were unusually shallow, often with only one cell. Such nests were made by bees with badly worn mandibles and wings; one with a fresh tumulus was found as late as October 24. Presumably these nests were second nests of senile bees. However a bee with only moderately worn mandibles and unworn wings was provisioning a normal nest on October 10. No cell provisioning was noted after that date.

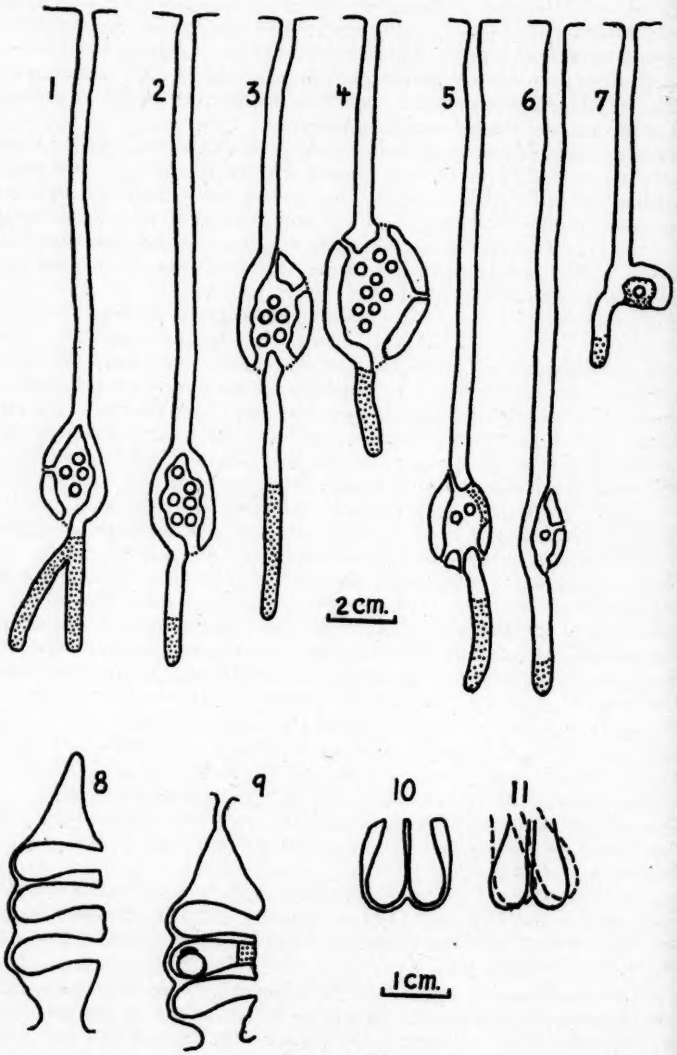
The success of the bees whose nests we observed during the spring (August to October) was in general poor. Very few produced larvae and pupae, and many never developed what seems to be a normal complement of cells. In some, after the bee had provisioned one or two cells, she merely remained in the nest, which stood open for weeks with the entrance partly closed by soil. One nest dug on September 26, at which time it had only two completed cells, had been marked on or before August 31. We do not know whether such slow progress is normal. It does appear probable that irregularity of activity and lack of synchronization is normal in this species.

On October 24 pupae were found in cells and it was therefore no surprise to find adult males and females on flowers on our visits to the area on November 18 and December 14. A single female taken from a freshly opened nest on November 23 had not mated and, of course, had the mandibles and wings unworn. Relatively few nests of this summer generation were found, perhaps because of the poor success noted above for the previous generation, at least in the nesting sites which we had investigated. On December 14, however, the bees were common on flowers! Of twenty-one specimens examined, all had the wings and mandibles not or only slightly worn and all had sperm cells in the spermathecae. The ovaries were mostly slender with the longest oocyte less than .8 mm. long, but a few already had large oocytes (up to 1.7 mm. long), and several were gathering pollen. On the same day three nests were excavated; two were new simple burrows but one was an old nest which had been opened and in which the occupant was beginning to store pollen in one cell.

In mid-January, 1956, both sexes were still on flowers, females still gathering pollen. Two nests excavated on January 13 lacked cells, but the bees had well worn mandibles, suggesting extensive work; possibly these were second nests of senile bees.

The small number of nests of the summer generation that we found precludes any detailed positive knowledge of the activities at this season, but it was evident that nests were constructed and provisioned and that a new brood of young was produced.

No individuals of *P. jocasta* were seen during February although it is very probable that some remain on the wing at that time. In mid-March,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however, a fresh unmated female was found making a burrow. Also, on March 24 in a nest newly opened to the surface, we found two females, both with unworn mandibles and wings, one mated, the other not. These bees presumably were representatives of the overwintering generation which provisions its nests in early spring. All had very slender ovaries and none had pollen in the gut.

NEST STRUCTURE

Each nest is a vertical burrow slightly narrowed at the entrance. The tumulus, about 3 cm. in diameter, is symmetrical around the burrow entrance. A few centimeters above the bottom, the burrow is enlarged to form a cavity. Sometimes, below this cavity, there are two or very rarely three more or less vertical burrows instead of one (fig. 1). The burrow below the cavity is often partially filled with loose dirt. As show nin Table I, the cavity is quite large and contains an earthen cell cluster which is separated from the walls of the cavity on all sides by a space of about 5 mm. The cell cluster is supported in the cavity by earthen pillars. The one at the bottom is usually largest, the one at the top often large, sometimes absent, often very delicate so that it breaks at a touch. Lateral pillars are ofen present and these, too, are often very delicate.

The construction of the cavity and cell clusters appears to be as follows, to judge by observations of nests of various ages: After completing the burrow, the bee starts to enlarge a section of it a few centimeters long to form the cavity. Soon she builds up in the center of the resulting spindle-shaped enlargement a slender vertical column of soil particles, so delicate that it breaks very easily. As further earth is removed from the walls of the growing cavity, at least part of it is added to the column to form the cell cluster.

Lateral pillars are usually (perhaps always) present during construction of the cell cluster but are delicate, being made of loosely bound particles. We believe, but are not completely certain, that the earth in the growing central column is added in such a way as to leave spaces for the cells; we have seen no evidence of the alternative hypothesis that the cells are excavated in the completed central column. It is not easy to get data relating to this matter for the central column is so fragile in new nests that it usually collapses as the nest is opened for study. Even a recently completed cell cluster is very friable except for the immediate vicinity of the cell walls and

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EXPLANATION OF FIGURES

1-7. Nests of *Paroxystoglossa jocasta*, with cell cluster facing forward, cell openings showing as small circles. 1-3, typical nests; 4, nest with unusually large cell cluster, possibly made by two bees working together; 5 to 7, nests made late in the season with small cell clusters. (No. 7 was unique, no similar nest was seen.) Dotted areas were full of loose soil.

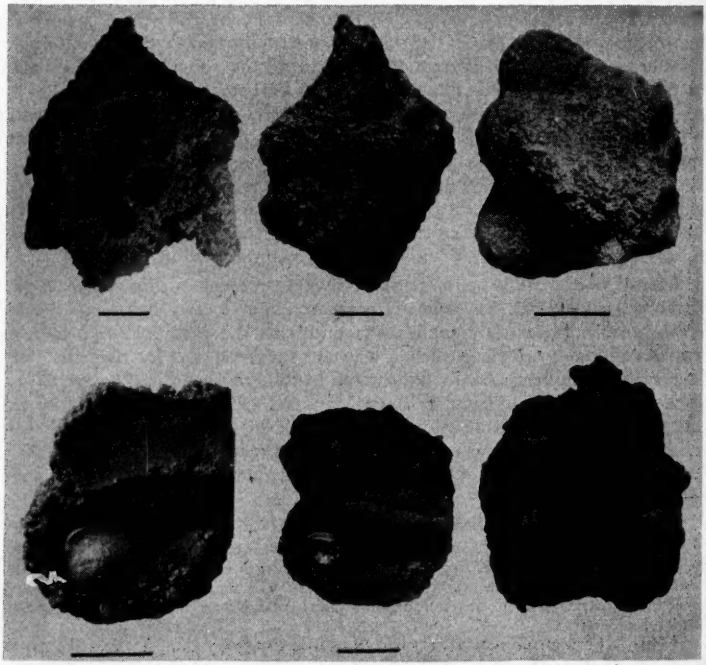
8 and 9. Vertical sections of cell clusters, cells opening at right. Note how the back of the cell cluster is thin walled and conforms to cells within; also in 9, how axes of cells diverge from the adjacent entrances. The center cell in 9 is closed and contains a pollen ball and an egg.

10. Horizontal section of cell cluster, showing how cells diverge from adjacent entrances.

11. Horizontal section of cell cluster showing how cells at different levels are often oriented differently.

the lower supporting column. As the cell cluster enlarges, lateral supports are reduced in number. After it is completed, it becomes hardened and can easily be lifted out of the cavity intact, only the lateral and upper pillars sometimes remaining friable. It seems certain that all of the cells of a cluster are constructed before any is used, for we never found clusters with one or more completed cells to which additional cells were being added at the sides. Often we found cell clusters with several unlined cells and only two or three, usually centrally located, cells lined with wax and only one of these being provisioned. From such data it seems that the bees normally wax one or two cells ahead of the one being provisioned, and that both waxing and provisioning start in centrally located cells.

We did excavate two nests (both on September 20) in which large cell clusters were principally solid soil and contained only two cells each (fig. 5), one or both of which was wax lined and being used. Such clusters would suggest that large solid clusters are constructed and that cells are subse-



12. Cell clusters of *Paroxystoglossa jocasta*. *Upper row*, complete clusters; *left*, from front (October), *middle*, from side (October), *right*, from above (November). *Lower row*, opened clusters; *left*, cluster cut vertically showing pollen ball and egg in one cell, part of another cell above (September); *middle*, cluster cut horizontally, upper cell with freshly hatched larva, lower with egg (September); *right*, cluster cut vertically to show thinness of walls (September). Each horizontal line represents 5 mm.

quently hollowed out in them and provisioned before other cells are made. This is contrary to the statements in the preceding paragraph based on many other nests. Both of the nests mentioned contained a female whose ovaries were slender except for one large oocyte in one ovariole of one ovary. We judge that these females were reproductively poor and that this is related to the small number of cells constructed. The lateness of the season might suggest that these were second nests, but the mandibles of the bees were not unusually worn (they were classified as slightly and well worn) and the wings were unworn. Therefore it seems unlikely that they were second nests.

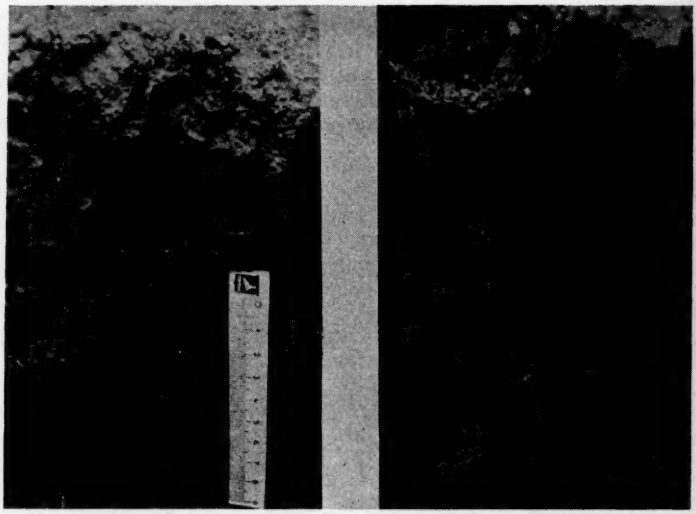
The system of constructing a cell cluster, supported by pillars in a chamber, occurs in many Halictinae in apparently unrelated sections of the subfamily. Additional examples among the South American metallic Halictinae will be described in subsequent parts of this series and have already been described by Claude-Joseph (1926). In Europe entirely unrelated forms such as *Halictus quadricinctus* (Fabricius) construct similar nests. Many such nests, like those of *Paroxystoglossa jocasta,* have cells with very thin walls, as indicated below. Verhoeff (1897) indicates his belief that the thin walls permit incubation of the brood, closed in the cells, by the adult bees.

The cells are elongate, with rather slender necks. They are essentially horizontal in position, although frequently their longitudinal axes diverge slightly so that all of the cells are not exactly horizontal (fig. 9). Ordinarily all the cells open on one side of the cluster, although in two nests observed one or two cells opened on the opposite side from the rest. The number of cells is indicated in Table I for presumably completed nests. We suspect

TABLE I
Measurements of Nests of *Paroxystoglossa jocasta*

	No. of measurements	Mean	Standard error of mean	Range	Units
Diameter of burrow	13	5.31	.133	5-6	mm.
Diameter of burrow entrance	4	3.06	.157	2.8-3.5	mm.
Depth of burrow	17	19.67	1.06	10-31	cm.
Depth to top of cavity	25	12.66	.65	6-15	cm.
Length of burrow below cavity	16	3.41	.242	2-5	cm.
Height of cell cluster	5	24.80	2.96	20-35	mm.
Breadth of cell cluster	9	16.44	1.25	11-23	mm.
Number of cells in complete normal clusters	18	5.66	.34	4-9	
Number of cells in mostly late and perhaps abnormal clusters	15	1.67	.187	1-3	
Height of cavity	20	34.10	1.511	25-45	mm.
Diameter of cavity	19	24.37	.62	17-30	mm.
Length of cell	39	13.54	.214	11-15.5	mm.
Maximum diameter of cell	38	5.67	.081	5.0-6.6	mm.
Diameter of cell neck	40	3.15	.042	2.6-3.6	mm.
Horizontal diameter of pollen ball	8	4.41	.112	3.9-4.9	mm.
Vertical diameter of pollen ball	7	3.40	.170	3.0-4.2	mm.

that nests with an unusually large number of cells (8 or 9) may have been made by two females working together but there is no certainty of this. Also shown in Table I are data on clusters of cells opened in late September or October; perhaps these were mostly second nests of senile bees, as suggested in a previous section. At their openings the cells are separated by earth walls, 1 or 2 mm. thick, less commonly as much as 4 mm. thick, but at the level of maximum cell diameter the cells approach one another closely, and the walls between them are usually only 0.5 mm. thick. The wall of the cell cluster which closes the posterior ends of the cells is similarly



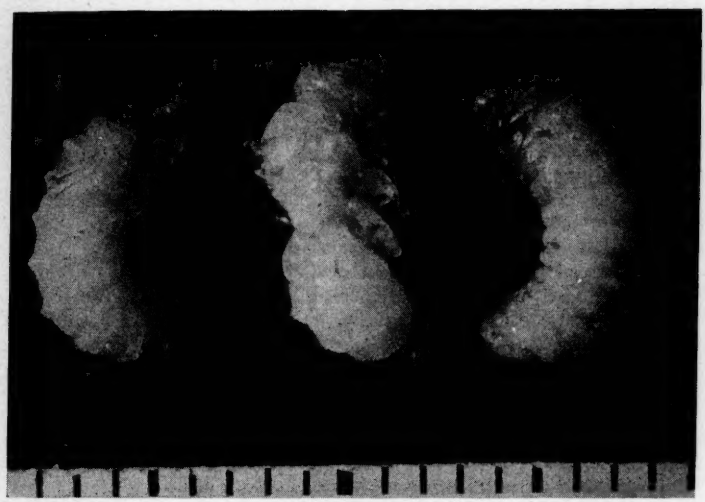
13 (left). Nest of *Paroxystoglossa jocasta* with small cell cluster of two cells (September). The scale is in centimeters. 14 (right). Nest of same, with rear view of cell cluster.

thin and seen from the outside conforms in shape to the cells, so that the positions of the cells can be seen from the back of the cell cluster (figs. 8, 9, 12). The cells ordinarily diverge posteriorly. When provisioned, a cell is closed by an earthen plug so that it is not visible or scarcely visible from the front of the cell cluster.

Completed cells are beautifully smoothed on the inside and then are lined, except for about 2 mm. at the entrance, by a shining waxlike material. Very commonly one or two cells in a nest remain unlined and unused. As mentioned above, all of the cells of a cluster are constructed before the first is waxed or used. The first cell to be waxed is ordinarily a central one; cells left unused are usually marginal ones. When nests are reused by a succeeding generation, the cell cluster is usually in good condition and cells are merely relined with wax. We have found cells with as many as three wax layers, indicating three usages. No feces intervened between the wax layers, indicating that they must have been cleared away before each

new layer was added. Sometimes, perhaps when the cell cluster is in bad condition, an old cluster is partially reconstructed and may consist in part of delicate, friable material like that of a new cluster.

Provisions of each cell consist of a ball of firm pollen and nectar flattened in the vertical axis, as indicated by the measurements in Table I. Cells observed in the process of being provisioned each contained a small pollen ball, less smooth than completed ones, and often there was dry pollen scattered about on the floor of the cell. Obviously the ball is formed progressively as load after load of pollen is brought to the cell. The white arcuate



15. Mature larvae and pupa of *Paroxystoglossa jocasta*. The scale across the bottom is in millimeters.

egg, which tapers toward the posterior end, is placed on top of the pollen ball. Eggs ranged from 2.3 to 2.6 mm. long, 0.6 to 0.8 mm. in maximum diameter (near anterior end); and 0.4 to 0.5 mm. in diameter near the posterior end.

SUMMARY

It seems that although there is irregularity in activity, there is a summer generation which provisions nests from which emerge an overwintering generation in the fall. Some of the overwintering bees probably provision cells in late summer, but most do so the following spring. Both sexes survive the winter as adults in the nests. From nests made in the spring emerge the members of the summer generation.

The bees are basically solitary, each female making her own nest in the soil, although occasionally two females were found in one nest. Old nests may be re-used, the cells merely relined with waxlike material, or new burrows and cells may be constructed. The cells are nearly horizontal, very

close together, in a cluster which is supported by slender earth pillars in a cavity in the ground.

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A COMPARATIVE STUDY OF THE FOREGUT OF SEVERAL AQUATIC HEMIPTERA[1]

EDWIN P. MARKS[2]

A number of authors have described the gut of the various aquatic Hemiptera. The earlier workers, Dufour (1833) and Locy (1884), described the structure of several members of this group, but the descriptions are vague and the illustrations give little if any usable histological detail. Marshall and Severin (1903), Neiswander (1925), and Hamilton (1931), collectively described *Ranatra* and *Nepa*. Poisson (1924) and Elson (1937) described the Belostomatidae, but only sketchily, and Bogiawlensky (1926) described the Notonectidae. Poisson (1924), Elson (1937), Griffith (1945), Slack (1946), and Sutton (1951) have all contributed to the knowledge of the Corixidae.

This study attempts to draw together the contributions of the above, investigate disagreements among them, and provide the additional information necessary for a detailed, comparative study of the foreguts of these groups of waterbugs. In addition to a search of the literature, one species from each family was selected and studied in detail. These species are as follows: Notonectidae, *Notonecta undulata* Say; Nepidae, *Ranatra fusca* P.B.; Belostomatidae, *Belostoma flumineum* Say; Corixidae, *Hesperocorixa escheri* (Heer).

From each species serial sections, both saggital and longitudinal, were prepared from the soft tissues of the gut. Bouin's, Carnoy's and Kahle's fixatives were used, and Mallory's triple stain, and Delafield's haematoxylin and acid fuchsin, were used on alternate slides. Since the condition of the gut varied greatly with the amount of food present, the insects were fed

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and then killed at known intervals following the feeding periods. Because of the use of multiple fixatives and time interval series, at least twenty-four specimens of each species were examined histologically.

The food pumps were examined primarily by microdissection. Both fresh and preserved material was studied. Free-hand saggital sections of freshly killed material were placed in glycerin until clearing had taken place. This gave a three dimensional view with nerves and muscles still in place. Occasionally light staining in acid fuchsin would improve visualization. In addition to this, complete dissections were made and the various structures operated by manipulation in order to ascertain relationships of parts. These methods were found to be superior to serial sections for visualizing the complete structures and facilitated the preparation of stereogrammatic illustrations. No attempt was made to record the number of dissections of each species.

There is a more or less general pattern of the foregut for all of the Cryptocerata. The food channel of the maxillary stylets receives the duct of the salivary pump and widens to form the cibarium proper which has apparently been incorporated into the forward portion of the food pump. The floor of the pump, and the forward portion of the pharynx itself, are heavily sclerotized in all of the forms studied. In the Notonectidae and the Corixidae, a portion of the pump is highly modified into a complex structure. The roof or diaphragm of the pump, the so-called epipharyngeal wall of Griffith (1945), is elastic and activated by strong dilator muscles. In the Belostomatidae, Notonectidae, and Corixidae, it is strengthened by various sclerotizations while in *Ranatra* it is apparently membranous. From the posterior end of the food pump, the oesophagus, a simple expansible tube lined with intima, leads to the midgut. It begins as a swelling or bulb just posterior to the food pump. In some forms, this swelling is provided with dilator muscles forming an accessory pump and ends in an invagination into the midgut often termed the oesophageal valve. The invaginated portion is lined with intima and, as in the Corixidae, is sometimes drawn out in a tube-like extension, the "etonnoir" of Aubertot (1934). The epithelium of the foregut terminates in a pad of enlarged cells. The intima covers this pad and then disappears into a crevice between this pad of cells and the midgut epithelium. This crevice is termed by Aubertot (1934) the "sillon" and is used by him as a landmark to indicate the posterior limits of the foregut.

THE FOOD PUMP

Griffith (1945) noted that the food pumps of *Notonecta* and *Ramphocorixa* include portions of both the cibarium and pharynx. This was determined by the positions of the dorsal dilator muscles of the various portions of the pump relative to the position of the frontal ganglion. Examination of the food pump of *Ranatra* shows little if any distinction between the cibarial and pharyngeal portions of the pump, either in the musculature or in the skeletal apparatus. As seen in Plate III, figs. 2, 4, 6, and 8, the only apparent difference is that the cibarial portion is attached firmly to the wall of the cranium, while the pharyngeal portion extends free into the cranial cavity. There is a slight constriction at the posterior margin of

the cibarial portion marking the point of juncture. The dilator muscles are uniform in structure along the pump. The entire pump forms a relatively straight line from the mouth to the foramen magnum. The head is completely prognathous. The roof of the pump shows no sclerotization except a weak thickening along the midline where the sclerotized threads attached to the dilator muscles are inserted.

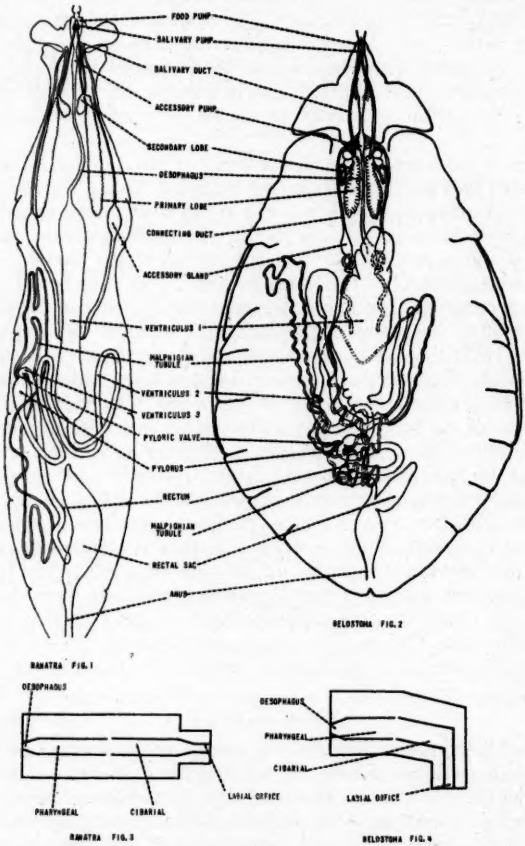

PLATE I

Fig. 1, Complete digestive tract of *Ranatra fusca*, gross aspects as seen in dissection. Fig. 2, Complete digestive tract of *Belostoma flumineum*, gross aspects as seen in dissection. Fig. 3, Diagrammatic representation of the head and food canal of *Ranatra* showing relative position of parts. Fig. 4, Diagrammatic representation of the head of *Belostoma* showing relative position of parts resulting from bending.

The food pump of *Belostoma* shows a clear distinction between the cibarial and pharyngeal portions. As shown in Plate III, figs. 1, 5, and 7, the dilator muscles of the anterior cibarial portion are different from those of the posterior or pharyngeal portions. The former are triangular in shape and are attached to the roof of the pump by means of sclerotized threads while the latter are more cylindrical in shape and appear to be attached

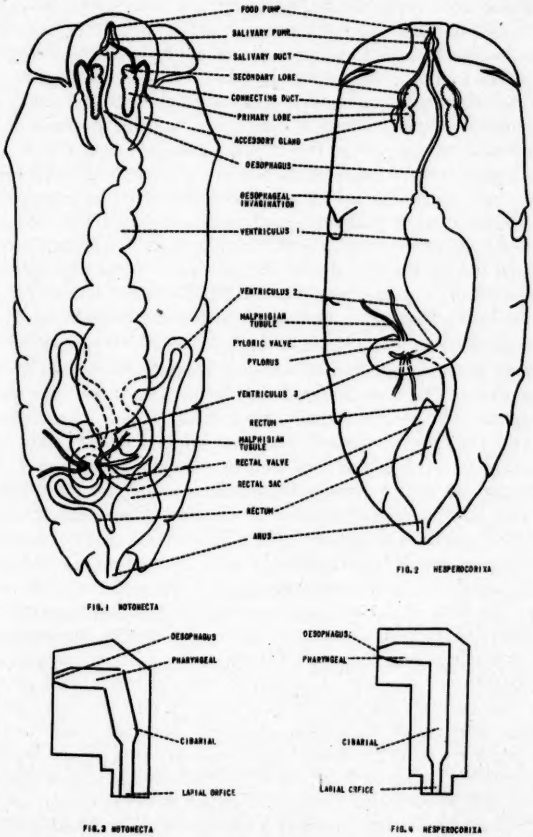

PLATE II

Fig. 1, Complete digestive tract of *Notonecta undulata*, gross aspect as seen in dissection. Fig. 2, Complete digestive tract of *Hesperocorixa escheri*, gross aspect as seen in dissection. Fig. 3, Diagrammatic representation of the head of *Notonecta* showing relative position of parts resulting from bending. Fig. 4, Diagrammatic representation of the head of *Hesperocorixa* showing relative position of parts resulting from bending.

directly to the roof of the pump. There is a pair of sclerotized bars which lie in the roof of the pump half-way between the midline and the lateral margin. These lateral bars, which are comma-shaped in cross section, project laterally into the lumen of the pump and appear to wipe the sides of the floor with their finely toothed edges. These lateral bars are unreported in the literature, having been mentioned by neither Elson (1937) nor Butt (1943), both of whom figured the pump of *Belostoma* from midsagittal sections. It has been suggested by Matsuda that these lateral bars may represent the hypopharyngeal suspensorium of Snodgrass (1928), since they occupy a position posterior to the opening of the salivary syringe into the cibarium. If this cibarial portion of the pump may be assumed to be in part derived from the wings of the hypopharynx, it is not difficult to see how the suspensorial apparatus might reach the present position in the epipharyngeal wall of the pump. Fig. 5, Plate III, and figs. 1 and 2, Plate V, show stereograms of this cibarial portion of the pump. As can be seen, there are no muscles attached to these bars. From the action of these structures in micromanipulated dissections, it is suggested that their function is perhaps one of directing and sweeping food rather than any masticatory action. This is born out by the diet of this insect which is not reported to include any solid food. The pharyngeal portion of the pump shows no sclerotization of the roof. The entire structure is somewhat reduced in size and partially separated from the cibarium by a distinct constriction.

The food pump of *Notonecta* is highly specialized. The head is strongly opisthognathous. The food pump is thus bent in an angle of approximately ninety degrees. The greater part of this bending appears to occur where the cibarial and pharyngeal parts of the food pump join. Awati (1914) describes a similar bend in the food pump of *Lygus paludinius* L. He, however, regarded the entire pump as pharyngeal in origin. Plate I, figs. 3 and 4, and Plate II, figs. 3 and 4, show, in diagram, the bending of the entire head. Plate V shows a series of views of dissections of the pumps of *Belostoma, Notonecta* and *Hesperocorixa.* Fig. 4 shows an enlarged parasagittal view of the pump of *Notonecta,* and fig. 3 shows a dorsal view of the same structure. The floor of the pump is heavily sclerotized along its entire length and is neither sharply bent nor articulated. The roof of the pump, however, contains two sclerotized bars which make a sharp, ninety degree bend. The anterior portion of the bar is articulated at the angle with the posterior portion. The anterior portions extend laterally and dorsally the length of the cibarial portion of the pump. At their posterior ends they articulate with the posterior portions of the bars, which are curved and blade-like, and bear a prominent comb of large teeth. These bars are joined at the midline where a single apodeme is formed to which a heavy group of muscles is attached. The anterior bars serve as a supporting framework for the roof of the cibarial portion of the pump. The posterior bars, suspended from the anterior bars and provided with heavy muscles, are movable in an anteroposterior plane. The dilator muscles of the pump are divided into three discrete groups. The first group dilates the roof of the cibarial portion, forming a powerful pump. The second group is attached to the apodeme of the posterior bars and is cibarial in origin. The third group dilates the

roof of the posterior portion of the pump behind the blades of the posterior bars, forming a second pulsating area. These muscles are pharyngeal in origin, being posterior to the frontal ganglion. The action of the entire structure can be demonstrated by micromanipulation. The first and third muscle groups activate separate areas of the roof to form pump-like structures. The second muscle group serves to swing the posterior bars forward and back in a rocking motion. This moves the toothed comb against the floor of the chamber creating a sweeping type of action. It is suggested that this action is a straining rather than masticating process. The author has encountered no reports nor any direct evidence that this insect ingests solid food. The suggestion, then, is that in both *Belostoma* and *Notonecta,* the sclerotizations in the food pump are rather for straining, directing, and breaking up clots in a liquid, or at best semisolid, food. Of the authors to date who describe the alimentary apparatus of *Notonecta,* apparently none has ascertained the complete structure of the food pump. Butt (1943) and Sutton (1951) overlook this straining device completely. Poisson (1924) and Griffith (1945) show midsagittal sections in which the teeth are visible but make no comments about the rest of the structure. Bogiawlensky (1926) gives the presence of teeth in the pharynx only passing notice. This is probably due to the fact that the midsagittal section (fig. 1, Plate IV) gives only a hint of what is found by dissection and micromanipulation.

The food pump of *Hesperocorixa* is also highly specialized. Plate IV, figs. 3 and 4, shows the cibarial portion of the pump which is elongated in conjunction with the elongation of the clypeal region which is characteristic of this family. The floor of this portion is weakly sclerotized and is supported, see Plate IV, fig. 3, for its entire length by the clypeal wall. The roof is uncomplicated and the musculature is uniform. Immediately behind this portion, there is a heavily sclerotized capsule, which is the masticatory chamber of Griffith (1945), Slack (1946) and Sutton (1951). The floor of the chamber is heavily sclerotized and is toothed and ridged. The roof of the chamber is much more complicated. Starting with the anterior edge of the capsule, the first prominent feature is the transverse fold which is lined with long hairs. Immediately behind this is a transverse sclerotized bar which bears a row of fine teeth on its anterior edge. It is formed from two pieces which are joined at the midline of the pump where they give off a single, well developed apodeme. In transverse section, the tail of the comma-shaped bar bears teeth, and as in *Belostoma,* projects into the lumen of the pump. The floor of the pump at this point also bears a series of teeth and ridges. Directly behind this is a second transverse bar of much the same structure as the first. The two are connected by articulations at the lateral margins and also by the roof of the pump. This second bar also bears a large apodeme in the midline. The floor opposite to it is smooth. A detailed account of the minute structure of this apparatus in *Sigara* is given by Sutton (1951). From her drawings and descriptions, these structures in *Sigara* are very similar to those in *Hesperocorixa.* Unfortunately she shows only the midsagittal view and thus misses the lateral aspects necessary to understanding the origin and operation of these structures. The oesophagus

emerges from this chamber as a delicate tube. A few weak muscles are attached to it at this point forming a small accessory pump.

Both Griffith (1945) and Sutton (1951) agree that the "Masticatory Chamber" includes the posterior portion of the cibarium and the anterior portion of the pharynx. The juncture between the two is thus part of the

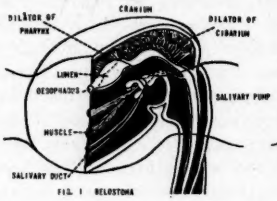

FIG. 1 BELOSTOMA

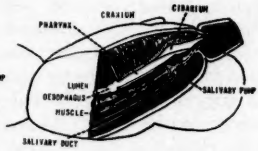

FIG. 2 RANATRA

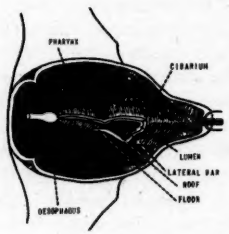

FIG. 3 BELOSTOMA

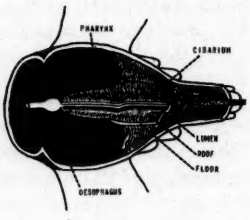

FIG. 4 RANATRA

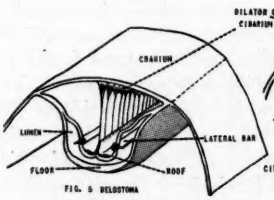

FIG. 5 BELOSTOMA

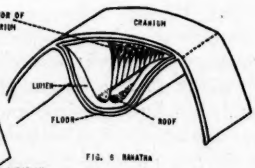

FIG. 6 RANATRA

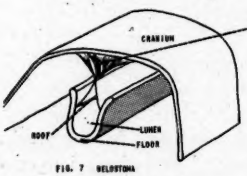

FIG. 7 BELOSTOMA

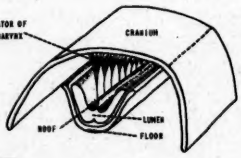

FIG. 8 RANATRA

PLATE III

Fig. 1, Stereogram of midsagittal aspect of the head of *Belostoma*. Fig. 2, Stereogram of midsagittal aspect of the head of *Ranatra*. Fig. 3, Ventral view of the wood pump of *Belostoma* with cutaway showing internal structure. Fig. 4, Ventral view of the food pump of *Ranatra* with cutaway showing internal structure. Fig. 5, Stereogram of transverse section of cibarial portion of food pump of *Belostoma*. Fig. 6, Stereogram of transverse section of cibarial portion of food pump of *Ranatra*. Fig. 7, Stereogram of transverse section of pharyngeal portion of food pump of *Belostoma*. Fig. 8, Stereogram of transverse section of pharyngeal portion of food pump of *Ranatra*.

chamber itself. This conclusion is born out by the following comparisons. In the simple type of pump found in *Ranatra,* the cibarial portion of the pump is attached to the wall of the cranium while the pharyngeal portion hangs free in the cranial cavity. The juncture between the parts is marked by a constriction. The musculature is uniform throughout. Breakey (1936), in describing *Anasa,* shows a similar situation except that the musculature of the two parts is distinct. In *Belostoma* the two portions are distinctly different both in skeletal and muscular structure. The cibarial portion in particular is strongly developed.

Let us now compare the pump of *Belostoma* with that of *Notonecta.* If the assumption is made that the sclerotized bars of *Belostoma* and *Notonecta* are homologous, or at least of similar origin (i.e., remnants of the hypopharyngeal suspensorium), an interesting spatial relationship between them becomes apparent. Comparison of figs. 1 and 3, Plate V, shows that if the bars of *Belostoma* were flexible and were grasped just behind the middle and pulled laterally and slightly to the rear, the results would resemble the same view of the pump of *Notonecta.* Looking now at figs. 2 and 4 of the same plate, the process is repeated, pulling upward. An articulation at the point of bending completes the picture. In this situation the posterior bars of *Notonecta* would represent the posterior one third of the lateral bars of *Belostoma.* It should also be noted that the posterior juncture of these bars occurs at the constriction used here to designate the point of juncture between the pharyngeal and cibarial portions of the pump. The muscles operating this bar are of cibarial origin as shown by their position relative to the frontal ganglion. The anterior portion of these bars has assumed a skeletal function and still retains its former relationship with the dilator muscles of the cibarium.

Superficial examination of the "masticatory chamber" of *Hesperocorixa* has led several authors to conflicting conclusions concerning comparisons with other members of the cryptocerata. Thus Slack (1946) apparently decided that the main difference between *Notonecta* and *Corixa* was the size of the teeth in the pump. Poisson (1924) notes that the Corixidae are unique among the cryptocerata in their possession of teeth in the pharynx, which he compares with similar structures in *Gerris.* Griffith (1945) and Sutton (1951) both seem to find little if any relationship between the Corixidae and Notonectidae in regard to the structure of the pharyngeal pumps.

If the same assumptions are made in the case of *Hesperocorixa,* that is, that the sclerotizations in the roof of the pump are remnants of the hypopharyngeal suspensorium, a similar set of relationships are found. Examination of figs. 5 and 6, Plate V, shows that in *Hesperocorixa* the anterior portion of the lateral bars is entirely missing. All of the sclerotizations are well behind the dilator muscles of the anterior pump, and largely behind the constriction marking the end of the cibarial portion. The only portions of the sclerotization associated with the cibarium are the inner ends of the anterior transverse bar and the associated apodeme. The position, anterior to the frontal ganglion, of the muscles operating this bar, and the location of the apodeme at the point of constriction suggest that this bar represents

the posterior portion of the lateral bars of *Belostoma*. This suggestion is further supported by a comparison with *Notonecta*. Figs. 3 and 5, Plate V, show that the lateral widening of the pump of *Hesperocorixa* is greatest behind the constriction. The anterior part of the cibarial portion has, at the same time, become greatly elongated. These simultaneous movements result in the lateral ends of the bars being pulled backwards while the inner ends are pulled anteriorly. A similarity in structure between this and the lateral bar of *Belostoma* can be seen by comparing the cross sections and the

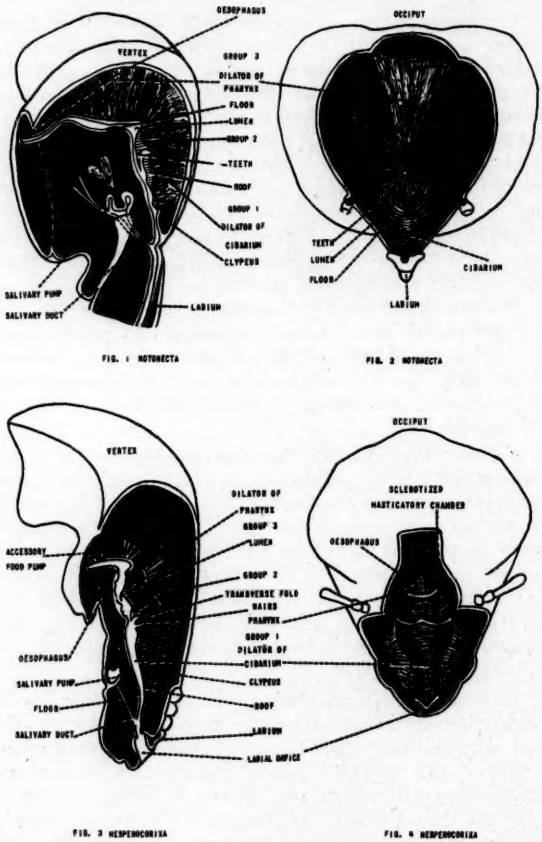

FIG. 1 NOTONECTA FIG. 2 NOTONECTA

FIG. 3 HESPEROCORIXA FIG. 4 HESPEROCORIXA

PLATE IV

Fig. 1, Stereogram of a transverse section through the head of *Notonecta*. Fig. 2, Ventral view of the food pump of *Notonecta* with cutaway showing internal structure. Fig. 3, Stereogram of a transverse section through the head of *Hesperocorixa*. Fig. 4, Ventral view of the food pump of *Hesperocorixa*.

structure of the teeth. Examination of the accessory bar, see Plate V, fig. 5, shows it to be of pharyngeal rather than cibarial origin. The muscles which activate it are behind the frontal ganglion and thus are the dilators of the pharynx and homologous with the third group in *Notonecta*. The pharyngeal origin of this bar is also demonstrated by its position relative to the constriction, being well behind it. This sclerotization then must have a separate origin in the roof of the pharyngeal portion of the pump.

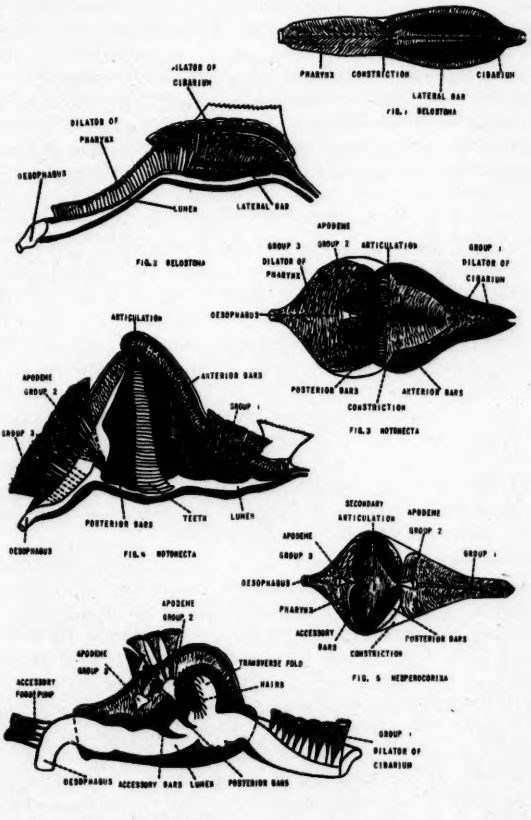

PLATE V

Fig. 1, Dorsal view of the roof of the food pump of *Belostoma*. Fig. 2, Lateral view of the pump of *Belostoma* with cutaway showing internal structure. Fig. 3, Dorsal view of the food pump of *Notonecta*. Fig. 4, Lateral view of the food pump of *Notonecta* with side cut away to show internal structure. Fig. 5, Dorsal view of the food pump of *Hesperocorixa*. Fig. 6, Parasagittal section of the food pump of *Hesperocorixa*.

From the comparison given above, it becomes apparent that the pumps of *Notonecta* and *Hesperocorixa,* while being similar in some respects, are neither, as Slack (1946) concluded, similar except for the nature of the teeth, nor, as Griffith (1945) and Sutton (1951) concluded, totally different. Poisson's report of similar teeth in *Gerris* and Sutton's report of a masticatory chamber in *Naucoris* lead one to regard such structures as being of more or less regular occurrence in the aquatic and semiaquatic forms. It is suggested then that the masticatory chamber of the Corixidae is a highly specialized development of sclerotizations already found in the pumps of other forms. It is also suggested that these sclerotizations are very possibly remnants of the primitive hypopharyngeal suspensorium. If this should prove to be the case, the masticatory apparatuses of *Hesperocorixa* and *Notonecta* might be considered to represent evolution in the direction of increasing complexity while the absence of any sclerotizations in *Ranatra* might be considered as representing evolutionary loss of these structures, both processes apparently occurring in the same phylogenetic group.

THE OESOPHAGUS

In the aquatic insects *Belostoma, Ranatra, Notonecta,* and *Hesperocorixa* there is a slight swelling or accessory pump in the oesophagus where it emerges from the food pump. See Plate I, figs. 1 and 2. In *Belostoma, Hesperocorixa,* and *Ranatra,* this bulb is provided with a few weak dilator muscles. Awati (1914), in describing *Lygus paludinius,* called it the "cardiac valve" and ascribed to it the function of preventing the regurgitation of food from the oesophagus into the pump. In *Belostoma,* a second such accessory pump is found at the point where the oesophagus emerges from the head proper. In all three of these forms, the oesophagus extends from this point to the midgut as a thin, simple tube. In *Notonecta,* such is not the case. In this form, the oesophagus is short and of larger diameter. The anterior end of the ventriculus is elongated and merges with the oesophagus so that the juncture is scarcely visible externally.

The histology is essentially similar in all four forms. The epithelium is composed of a single layer of cuboidal cells covered by a thin layer of longitudinal muscle. The entire structure is capable of considerable distension during feeding. Starvation causes the intima lining to be thrown into deep longitudinal folds. Fig. 1, Plate VI, shows a cross section of the oesophagus of *Belostoma* in the unfed state. Longitudinal sections are shown in Plates VI and VII. The point at which the oesophagus joins the midgut is far more interesting from a comparative point of view than is the oesophagus proper. This region has been given various names by different authors. It will be referred to here as the oesophageal invagination, since the epithelium is actually invaginated, to some degree, into the ventriculus proper. In *Ranatra,* the most conspicuous feature of the invagination is a large terminal pad of elongated, epithelial cells at the point of juncture of the foregut and midgut epithelium. This is conspicuous in the starved condition and is much reduced in the fully fed condition. A second feature is the shallow fold just above the terminal pad in the foregut epithelium. This fold is rather conspicuous in the starved condition and is almost obliterated during

feeding. It is marked externally by a layer of circular muscle which forms the sphincter and indicates the beginning of the midgut. The intima of the foregut is closely applied to the surface of the cells and disappears into the groove between the terminal pad and the midgut epithelium. The size and shape of the invagination changes considerably with the amount of food present and the duration of the period of starvation since the last feeding. This may account for the differences in the descriptions of this structure by various authors who apparently considered the shape to be somewhat more stable than it really is. The structure of this invagination appears to bear out the suggestion that it serves to prevent the regurgitation of food into the oesophagus.

The oesophageal invagination of *Belostoma* shows the same basic pattern as does that of *Ranatra*. The terminal pad of the foregut is present, but somewhat reduced in size. The oesophageal fold, however, is much more prominent and is present in all stages of feeding. The relationship between the pad and the fold is illustrated in figs. 2, 3, and 5, Plate VI. In the starved condition, the terminal portion of the oesophagus is deeply invaginated into the midgut. This is apparently due to the enlargement of the cells and the thickening of the midgut epithelium which occurs in starvation. After feeding (Plate I, fig. 3), the gut has become distended with food. The oesophageal invagination is compressed upward by the pressure of the food. The walls are thrown into deep folds, which are similar to those found in *Ranatra*. As the thickness of the midgut wall is reduced following feeding, the depth of the folds is decreased until the structure becomes a simple invagination with a single fold. As the midgut epithelium increases in thickness again with prolonged starvation, the depth of the invagination increases until feeding occurs and the cycle is repeated. Comparison of the invaginations of *Ranatra* and *Belostoma* show the same structures and the same changes during the feeding cycle. The main differences are in the degree of folding and the size of the terminal pad. In *Ranatra* the terminal pad is large and the folds simple, shallow, and, at times, disappearing almost completely. In *Belostoma*, the pad is reduced and the folding is complex and always present.

The region of the oesophageal invagination of *Notonecta* is difficult to locate externally. The reason for this becomes evident when longitudinal sections are studied. As can be seen in figs. 5, 6, and 7, Plate VII, only in the starved condition is there any distinct invagination. The terminal pad is small and the fold is poorly represented, being virtually absent following feeding. The presence of the pad and the sphincter, however, are enough to suggest that this condition is probably the result of reduction from a more complicated structure. The intima clings tightly to the foregut epithelium and ends in the groove which marks the posterior end of the terminal pad. Some authors have missed this structure entirely. Harris (1938) reports a similar structure in *Oncopeltus fasciatus* (Dallas).

If *Notonecta* represents one extreme of the development of the oesophageal invagination, then *Hesperocorixa* represents the other, among the insects studied. *Notonecta* represents extreme reduction. *Hesperocorixa* represents a very high level of complexity. The complex oesophageal invagination

of the Corixidae has been studied by Sutton (1951) in both the nymphal and adult stages. The epithelium of the oesophagus is invaginated deeply into the ventriculus. As shown in figs. 1, 2, 3, and 4, Plate VII, the oesophageal fold is very deep and carries with it some muscle strands which prob-

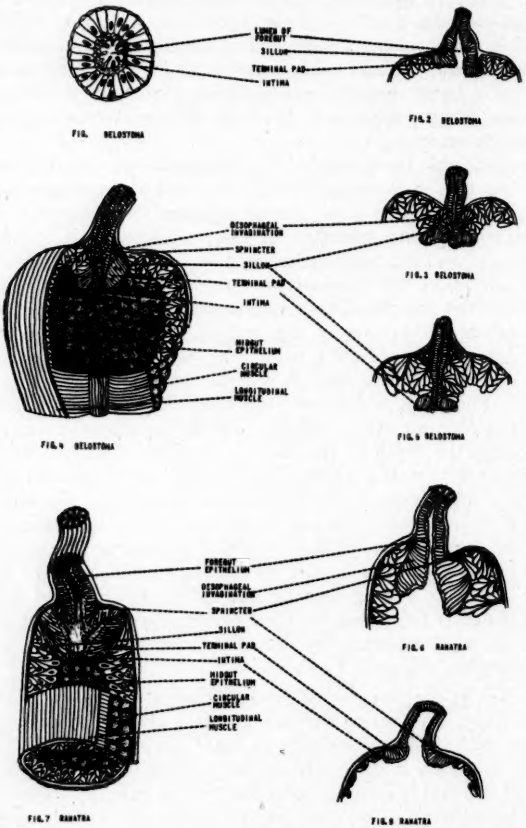

PLATE VI

Fig. 1, Transverse section of the oesophagus of *Belostoma*. Fig. 2, Midsagittal section of the oesophageal invagination of *Belostoma* (Fed 2 hours). Fig. 3, Midsagittal section through the oesophageal invagination of *Belostoma* (Starved 4 hours). Fig. 4, Stereogram of the oesophageal invagination of *Belostoma* with cutaway to show the microscopic section (Starved 36 hours). Fig. 5, Midsagittal section through the oesophageal invagination of *Belostoma* (Starved 84 hours). Fig. 6, Midsagittal section through the oesophageal invagination of *Ranatra* (Starved 60 hours). Fig. 7, Stereogram of the oesophageal invagination of *Ranatra* with cutaway to show the microscopic section (Starved 36 hours). Fig. 8, Midsagittal section through the oesophageal valve of *Ranatra* (Fed 2 hours).

ably reprsent the sphincter. Between the two layers of foregut epithelium are sinuses which, according to Sutton, are filled with blood. The intima lining the oesophagus projects beyond the end of the invagination and extends deep into the lumen of the ventriculus. This membrane has been

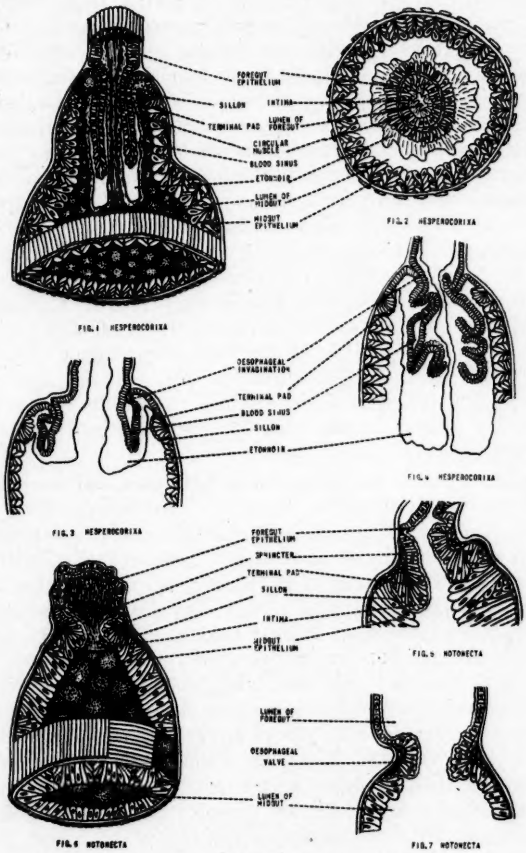

PLATE VII

Fig. 1, Stereogram of the oesophageal invagination of *Hesperocorixa* with cutaway to show microscopic structure. Fig. 2, Transverse section through the oesophageal invagination of *Hesperocorixa*. Fig. 3, Midsagittal section through the oesophageal invagination of *Hesperocorixa* (Fed 6 hours). Fig. 4, Midsagittal section through the oesophageal invagination of *Hesperocorixa* (Starved 60 hours). Fig. 5, Midsagittal section through the oesophageal valve of *Notonecta* (Starved 60 hours). Fig. 6, Stereogram of the oesophageal invagination of *Notonecta* with cutaway to show microscopic structure. Fig. 7, Midsagittal section of the oesophageal invagination of *Notonecta* (Fed 4 hours).

designated the "etonnoir" by Aubertot (1934) to distinguish it from a peritrophic membrane which it superficially resembles. The forward portion of the midgut which surrounds the upper portion of this invagination has been called, by Sutton, the "proventriculus." She regards this region as a now functionless remnant of the proventriculus of other orders. Her argument is based primarily on the statement that this portion never contains food since the "etonnoir" prevents its entry by acting as a valve. Thus, she reasons that it represents the area from which a peritrophic membrane was at one time secreted. This argument, in my opinion, is scarcely sufficient to warrant the use of the term "proventriculus" which has quite a different meaning in other groups. In the present study a slight constriction was found at the level of the invagination and the cells in this area were somewhat smaller. Nothing was found in this area which could be identified as a proventriculus or a peritrophic membrane. The size and shape of this structure varies considerably with the stage of feeding. The invagination itself is a rather delicate and flexible structure. Whether this represents a primitive or specialized condition may be difficult to ascertain. Deep oesophageal invaginations are reported by Lincent (1912) for Cercopidae and Fulgoridae (Homoptera), and by Breakey (1936), Harris (1938), and Goodchild (1952) for various of the Hemiptera. Sutton suggests that *Naucoris,* which lacks the "proventriculus" and well developed valve in some forms, may represent an intermediate stage. The presence of the "etonnoir," the "blood sinuses," and the "proventriculus" appear to be unique to the Corixidae.

The point at which the foregut epithelium ends and the midgut epithelium begins seems to be the subject of confusion in some of these forms. As Aubertot (1934) points out, the structure of this transitional area is widely varied among the orders of insects. Lincent (1912), Harris (1938), and Breakey (1936) appear to agree. Breakey describes an area labeled as "X" which he suggests represents foregut epithelium without intima and calls it the "peritrophic area." Poisson (1924), Harris (1938) and Goodchild (1952) all show the foregut ending in a pad of cells covered by intima, which is extremely thin and tightly applied to the surface of the cells. It is this pad of cells which appears in all four of the forms presented in this study. In *Hesperocorixa* this pad of cells is small and not well differentiated. As in the other forms, the intima covering these cells is extremely thin and closely applied to the surface. The author suggests that the "proventricular cells" of Breakey probably represent this pad of cells, as the intima is very thin and often difficult to detect. Sutton (1951) apparently regarded this pad of cells as belonging to the midgut epithelium, and behind the true "sillon." Since this pad is demonstrably covered with a layer of intima, it must, morphologically, belong to the foregut and thus, by definition, lie in front of the "sillon." The pad itself must, then, be comparable to the "cellules de la zone annulaire" which Aubertot found in such widely divergent insects as the nymph of *Aeshna* and the larva of *Tanypus.*

With the few exceptions mentioned, the observations of the author on *Hesperocorixa* agree well with those of Sutton on *Sigara* and *Corixa,* with regard to the oesophageal invagination.

The external similarities between the oesophageal invaginations of *Notonecta* and *Hesperocorixa* are more apparent than real. A histological examination reveals that these two stand rather at opposite ends of the scale as regards development of the pads and folds. We find in *Ranatra* and *Belostoma* what might be considered morphologically intermediate structures. *Hesperocorixa* with the reduced pad and exaggerated folding is more like *Belostoma. Notonecta,* with reduced folding and prominent pad, more closely resembles *Ranatra.* Again we find what appear to be two different lines of development, one of increasing complexity and one of decreasing complexity. What may be regarded as primitive in this case seems questionable. Sutton's proposal that the complex valve of the Corixidae is primitive does not appear to be supported by this study.

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THE *THEODORA* GROUP OF *ACRONICTA* OCHSENHEIMER AND A NEW NAME FOR *ANYTUS* GROTE (Lepidoptera, Noctuidae)

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The genus *Acronicta* Ochsenheimer has been variously subdivided into species groups, sections, or subgenera according to the kind of vestiture of the thorax, the kind of male genitalia, and the nature and placement of larval setae. The three species treated in this paper differ in the shape of the apices of the parameres (valvae) of the male genitalia from all the other known American species of *Acronicta*. The apices of the parameres are produced ventrally in the species treated whereas in the other species of the genus those parts are rounded or bluntly pointed. In consideration of the difference in the male genitalia and until such time as larvae of the three species are available for comparative study, the adults may be considered as belonging to a distinct species group, the *theodora* group.

One of the included species, *Acronicta atristrigata* (Smith), was originally and has been subsequently incorrectly placed in the genus *Anytus* Grote (type of genus, *Xylina sculpta* Grote, designated by Grote, 1874, Bull. Buffalo Soc. Nat. Sci., 2:27). The species of the cuculliine genus, *Anytus,* have weak lashes about the eyes, spines on the mid- and hind-tibiae, and the front femora normal (not greatly enlarged and swollen as in many species of *Acronicta*). *Anytus* Grote, 1873, Bull. Buffalo Soc. Nat. Sci., 1:144, is preoccupied by *Anytus* Stål, 1865, Hemiptera Africana, v. 3, p. 74. For the species currently placed in *Anytus* Grote, I propose the anagram, *Sutyna,* n. n. The type of *Sutyna* is, of course, *Xylina sculpta* Grote.

Acronicta theodora Schaus

(Figs. 2, 4, and 7)

Acronycta theodora Schaus, 1894, Trans. Amer. Ent. Soc. 21:223. Druce, 1898, *in* Godman and Salvin, Biologia Centrali-Americana, Insecta, Lepidoptera, Heterocera, v. 2, p. 472, v. 3, pl. 93, fig. 3. Hampson, 1909, Catalogue of the Lepidoptera Phalaenae in the British Museum, v. 8, p. 62, pl. 124, fig. 9. Barnes and McDunnough, 1917, Check list of the Lepidoptera of Boreal America, p. 64, sp. no. 2426.

Acronicta theodora Schaus. Draudt, 1924, *in* Seitz, Gross-schmetterlinge der Erde, .v 7, p. 21, pl. 3, row b. McDunnough, 1938, Check list of the Lepidoptera of Canada and the United States of America, Part 1, Macrolepidoptera, Mem. So. California Acad. Sci., v. 1, p. 56, sp. no. 1179.

Anytus theodora (Schaus). Dyar, 1903, List of North American Lepidoptera, Bull. 52, U. S. Nat. Mus., p. 150, sp. no. 1754 [in part ?].

This species may be separated from *A. atristrigata* (Smith) and *A. beameri,* n. sp. by the maculation of the forewing and the distinctive genitalia of the male (see fig. 4). The stout black dash between the postmedial and antemedial bands is caudad of the fold and not in line with the basal and distal dashes of the fold of the forewing. In *atristrigata* the median dash is thin and in line with the other dashes of the fold. *A. beameri,* n. sp. lacks a black dash in or beside the fold between the medial shade and the antemedial band. Length of forewing: male and female, 18 to 19 mm.

Type. In the United States National Museum, Washington, D.C., type number 18765.

Type locality. Jalapa, Mexico.

Distribution. The nine specimens of this species in the collection of the United States National Museum are from the following localities in Mexico: *Veracruz,* Jalapa and Orizaba; *Morelos,* Zacualpan. Druce identified a specimen or specimens from Guatemala City, Guatemala, as this species. In Dyar's (1903) statement "Ariz., & Mex." the first locality probably was taken from one or both of the specimens described herein as *A. beameri,* n. sp.

Acronicta atristrigata (Smith), n. comb.
(Figs. 1 and 5)

Anytus atristrigatus Smith, 1900, Proc. U. S. Nat. Mus. 22(1203):460. Dyar, 1903, List of North American Lepidoptera, Bull. 52, U. S. Nat. Mus., p. 150, sp. no. 1755.

Anytus atristrigata Smith. Hampson, 1903, Catalogue of the Lepidoptera Phalaenae in the British Museum, v. 4, p. 586, pl. 76, fig. 7. Barnes and McDunnough, 1917, Check list of Lepidoptera of Boreal America, p. 47, sp. no. 1535. Draudt, 1924, *in* Seitz, Gross-schmetterlinge der Erde, v. 7, p. 77, pl. 12, row a. McDunnough, 1938, Check list of the Lepidoptera of Canada and the United States of America, Part 1, Macrolepidoptera, Mem. So. California Acad Sci., v. 1, p. 85, sp. no. 2286.

In general habitus *atristrigata* resembles *theodora* and *beameri* but differs from those species as indicated in the diagnosis of *theodora* and by the distinctive male genitalia (see fig. 5). Length of forewing: male, 17 to 18 mm.; female, 18 mm.

Type. Smith described this species from two males and one female from "Texas." In the original description Smith stated: "*Type.*—Cat. No. 4812, U. S. N. M." Inasmuch as Smith did not have a holotype concept and since the "♂ type" and "♀ type" both bear U. S. N. M. type number 4812, I select the specimen labeled "♂ type" in the collection of the United States National Museum to be the lectotype of *Anytus atristrigatus* Smith. The third specimen of the type series, "♂ cotype," is in the collection of the American Museum of Natural History, New York, N.Y.

Type locality. The lectotype is labeled "Tex."

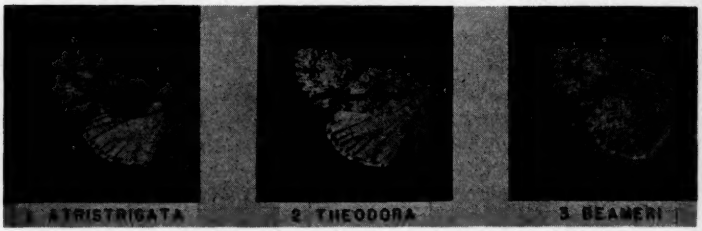
Distribution. No specific locality is known for the three specimens of the type series. However, there is in the United States National Museum a male collected by J. C. Gaines, April 6, 1955, at College Station, Texas.

Acronicta beameri, n. sp.
(Figs. 3, 6, and 8)

Anytus theodora (Schaus). Dyar, 1903, List of North American Lepidoptera, Bull. 52, U. S. Nat. Mus., p. 150, sp. no. 1754 [in part ?].

Head with front slightly exceeding eyes; eyes moderately large, globoid, naked; ocelli present, small; antennae filiform; labial palpi oblique, not exceeding dorsal margin of eye; vestiture of head mostly of grey hairlike scales, some black scales around antennae, a black transverse band on the front, a black patch on the dorsal margin of the first segment and a black oblique band on the second segment of the labial palpus. Patagia and tegulae grey with some black scales along the dorsal margins, the black markings of the patagia heavier than those of the tegulae. Abdomen grey with a suffusion of brown scaling; the segments, especially the more basal ones, covered with fine golden-brown hair; dorsal tufts of scales lacking except on basal segment. Front femur greatly enlarged, distinctly larger than femora

of mid- and hind-legs, a furrow present on the ventro-lateral margin; vestiture of legs of grey scales but with the ventro-lateral area laterad of the furrow of the front femora, the bases of the tarsal segments and oblique areas of the tibiae dark-scaled. Forewing slightly more than twice as long as wide (18:8); termen more or less rounded, slightly concave caudad of Cu_1; venation of trifid type; ground color of forewing ash-grey, powdered with brown scaling; costal margin with seven short, dark, oblique marks, representing the elements of basal, antemedial and postmedial bands and the median shade; three small, black points present on costa distad of the oblique marks; antemedial band irregular, most strongly marked in area of fold; median shade conspicuous at costa, indistinct and serrate toward inner margin; postmedial band with outer element most distinctly marked, strongly serrate, bent basad along Cu_1; subterminal line represented by a

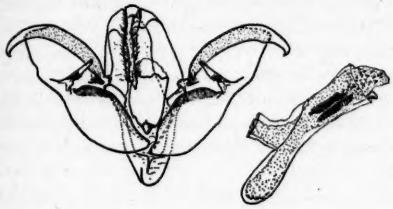


Figures 1-3, dorsal view of wings of left side of adults of the *theodora* group of *Acronicta* Ochs. (Figures slightly smaller than natural size.)

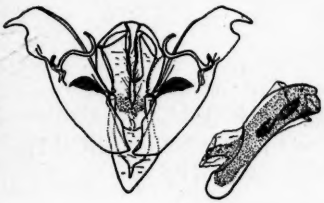
series of pale brown spots in anterior half of wing; small, black, wedge-shaped terminal spots present between the veins; fringe checkered; reniform moderately well marked, ovoid, centered with brown and completely margined by a thin, dark brown line; orbicular round, centered with pale brown, bordered with white, completely margined by a thin, dark brown line; basal, anal (distal), and apical dashes pesent, medial dash present only between postmedial band and median shade. Hind wing hyaline, suffused with pale fuscous, the latter more prominent toward the outer margin and on the veins, hind wings of female slightly darker than those of male; postmedial line present, produced toward margin on M_3, outwardly concave between Cu_1 and 2nd A. Underside of wings pale hyaline except anterior half of forewing suffused with brown; discal and terminal spots distinct. Length of forewing: male, 18 mm.; female, 19 mm.

Male genitalia specifically distinct (see fig. 6); larger than those of *theodora* and *atristrigata;* costa of paramere sclerotized, produced apically, some irregular dentations present on the inner margin of the sclerotization before the apex, apex digitiform; transverse process of the mesal surface of paramere[1] elongate, bowed, a small recurved hook at apex; juxta large,

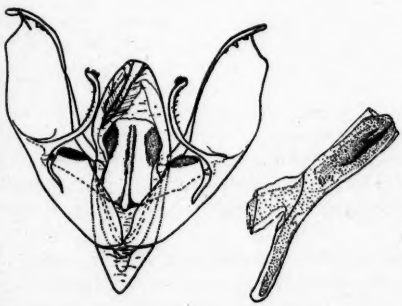
[1] This is one of the processes of the structure termed "clasper" by Forbes, 1954, Lepidoptera of New York and Neighboring States, Part 3, Mem. 329, p. 13, issued by Cornell University Agricultural Experiment Station. Because of the dorsal point of origin (see fig. 4) and the presence of minute setae (see figs. 5 and 6), I believe that this is the structure identified as the ampulla of the clasper in other noctuids.



4. THEODORA

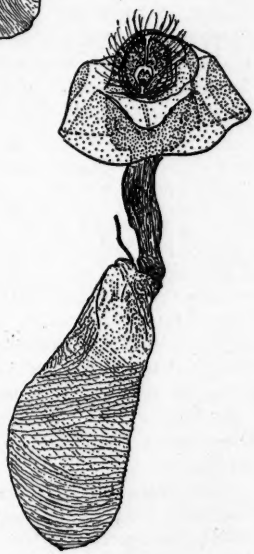


5. ATRISTRIGATA



6. BEAMERI

7. THEODORA



8. BEAMERI

Figures 4-6, male genitalia of species of the *theodora* group of *Acronicta* Ochs. (Aedeagus removed and figured to the side of the remainder of the genitalia); figures 7-8, female genitalia.

semicylindrical, partially keeled medially, scobinate patches present dorsolaterally; proximal end of aedeagus slightly longer and less robust than corresponding part in *theodora* and *atristrigata*.

Female genitalia (see fig. 7) similar to those of *theodora* (genitalia of the female of *atristrigata* destroyed by dermestids and not available for comparison), but with the caudal margin of the sternal plate of the seventh segment more distinctly notched, the vagina larger and more rectangular, and the ductus bursae shorter.

Type. Holotype, male, Palmerlee, Cochise County, Arizona, U. S. N. M. type number 64131, and one female paratype, Huachuca Mountains, Arizona, July 24-31, in the United States National Museum.

Remarks. This species may be easily separated from *theodora* and *atristrigata* by the absence of a medial dash between the median shade and the antemedial band of the forewing and by the distinctive male genitalia. The species is respectfully named in memory of Dr. R. H. Beamer.

FAUNAL AFFINITIES OF ARIZONA *PHYLLOPHAGA*, WITH NOTES AND DESCRIPTIONS OF NEW SPECIES (Coleoptera, Scarabaeidae)

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The Arizona *Phyllophaga* as a whole are very different in their characteristics from the majority of the 200 species of the genus known to occur in the United States. Not until an investigation of the Mexican fauna was commenced did it become apparent that the affinities of the Arizona species are almost totally with that fauna which, in turn, has a close relationship to the Central and South American elements. Previous studies by Horn (1887), Sim (1928), Böving (1942), and Luginbill and Painter (1953), treating *Phyllophaga* s. str. or large sections of the genus in the United States, did not take into account these affinities, but Chapin (1935) and Saylor (1939, 1940, 1942), in their treatments of the then considered genera or subgenera *Chlaenobia, Phytalus,* and *Listrochelus,* did see these relationships.

The present study is designed to show that most of the 43 species of *Phyllophaga* known to occur in Arizona are representatives of larger groups occurring in Mexico. Indeed, one half of the Arizona species occur also in Mexico. Included in this report is a key to nine groups which also includes the subgenus *Listrochelus*. References to the literature and other aids are given for the recognition of each species in Arizona, and two new Arizona records, four new species, and some new synonymy are included.

In the course of my studies on *Phyllophaga,* many Arizona records have been assembled, and the types of nearly all species known from that state

have been examined. I am indebted to many institutions and individuals for submitting collections for study. Dr. R. H. Beamer and many students and staff members at the University of Kansas have collected *Phyllophaga* extensively in Arizona. I am especially grateful to Dr. Floyd G. Werner and Dr. George D. Butler of the University of Arizona (UA) for the opportunity of studying collections made by them during the past few years, some localities having been visited at my suggestion. To Dr. J. N. Knull of Ohio State University (OSU), Dr. Mont A. Cazier and his associates at the American Museum of Natural History (AMNH) and to various collectors associated in the past or at present with the University of California (UC) and the California Academy of Sciences (CAS), I am grateful. Mr. Owen Bryant of Montara, California, the United States National Museum, and my colleague, Dr. Richard B. Selander, have contributed significantly to these records. Through an arrangement with Dr. George A. Butler, most of the *Phyllophaga* records which were assembled for Arizona are to be published elsewhere, but certain pertinent records are included in the present report.

The identification of certain species considered in the synonymy has been made possible through the very generous gesture of Dr. K. Delkeskamp of the Humboldt University in Berlin who sent me for study the types of many of the Tropical American *Phyllophaga* described by J. Moser between 1918 and 1924. The study of this important collection has made it possible to accelerate an investigation of the Neotropical fauna and has affected the interpretations of names for several of the species described from the United States.

The following key to the groups of *Phyllophaga* represented in Arizona is based in part on secondary sexual characters of the male abdomen and tarsal claws, especially of *ravida* Blanch. In the group discussions these features are supplemented by descriptions or reference to the male genitalia. Other characters showing similarities between the sexes in most groups include the number of antennal segments, presence or absence of dorsal hairs, and characteristics of the tarsal claws.

Key to Subgenera and Groups of Arizona Phyllophaga

Males

1. Lower margin of tarsal claw usually pectinate (as in fig. 1) or denticulate, the pectination or denticles extending nearly full length of claw; head usually transversely ridged next to anterior margin of pronotum ..... subgenus *Listrochelus*
   Lower margin of tarsal claw rarely finely denticulate, denticles, if present, between apex of tooth of claw and base of claw; claw usually toothed as in figs. 2 to 5; head without transverse ridge next to anterior margin of pronotum ..... subgenus *Phyllophaga*—2
2. Body black in Arizona species; metasternum short; crepuscular .... *cribrosa* group
   Body not black; metasternum long; nocturnal 3
3. Claws on middle pair of legs dissimilar, the lower tooth of one claw offset (fig. 2a), the opposite claw with lower tooth in middle of mar-

gin (fig. 2b) ..... *ravida* group
All tarsal claws similar 4

4. Antenna 9-segmented; dorsum hairy ..... *multipora* group
Antenna 10-segmented 5

5. Anterior margin of last abdominal sternite elevated, the apex or crest of elevation narrowly emarginate or bearing a flattened bilobed process ..... *anodentata* group
Last abdominal sternite without modifications 6

6. Pronotum strongly narrowed anteriorly and posteriorly, the dorsal surface coarsely and irregularly punctured; last one, or two abdominal sternites sloping toward apex of abdomen; tarsal claw cleft as in fig. 3 ..... *blanchardi* group
Pronotum parallel or nearly so in basal half, the dorsal surface more finely and evenly punctured; last abdominal sternites not as described above; tarsal claws variable 7

7. Tarsal claw distinctly cleft (fig. 4) ..... *obsoleta* group
Claw with a vertical tooth on lower margin (fig. 5) 8

8. Dorsum evenly covered with hairs ..... *setidorsis* group
Dorsum usually glabrous, at most with a few hairs arranged in narrow longitudinal groups ..... *ignava* group

SUBGENUS *Listrochelus*

This subgenus in the United States was adequately treated by Saylor (1940) for identification purposes and includes the following species from Arizona, in addition to twenty-five species known only from Mexico: *arizona* Saylor, *cochisa* Saylor, *cushmani* Saylor, *chapini* Saylor, *duncani* Barrett, *disparilis* Horn, *eligia* n. sp., *falsa* LeConte, *fimbripes* LeConte, *flavipennis* Horn, *granti* Saylor, *huachuca* Saylor, *luginbilli* Saylor, *mucorea* LeConte, *nogales* Saylor, *opacicollis* Horn, *plena* Fall, *scoparia* LeConte, *tarsalis* Schaeffer, *timida* Horn, *trochanter* Saylor, *wickhami* Saylor, and *snowi* Saylor. With *Listrochelus,* I would reunite the Arizona *juvenilis* Fall (1929) described as a *Listrochelus* but not included in the subgenus by Saylor. The tarsal claws of *juvenilis* are finely denticulate and its position in *Listrochelus* is probably as satisfactory at present as in any other group of the genus. The species was redescribed and illustrated by Luginbill and Painter (1953). The male genitalia are variable in this subgenus and present no distinctive features for group recognition.

Phyllophaga (Listrochelus) luginbilli Saylor

Phyllophaga (Listrochelus) luginbilli Saylor 1941:145.

Saylor described this species from one male collected at Grant[s], New Mexico, June 14, 1939. In addition to examining the type I have identified two males from Magdalena, New Mexico, Strickler, collector (KSC), and three males collected in the Huachuca Mountains, Arizona, July 12, 1953, by D. J. and J. N. Knull (OSU). The first illustrations of the male genitalia (figs. 6 and 7) are included with the presentation of these new records.

Phyllophaga (Listrochelus) nogales Saylor, new status
Phyllophaga (Listrochelus) falsa nogales Saylor 1940:99.

This is a distinct species and not a subspecies of *falsa* LeConte as described by Saylor. Saylor distinguished *nogales* from typical *falsa* by its pruinose instead of glabrous pronotum, absence of clypeal hairs (present in *falsa*), and the narrower first posterior tarsal segment (about three times longer than apical width in *nogales*, two times longer in *falsa*). He could find no differences in the male genitalia. Close examination of the genitalia has disclosed that the angled apex of each paramere in *nogales* is dorsoventrally flattened and rounded on the apical margin (not so pointed as shown for *falsa* in Saylor's figure 9a in his 1940 revision). The left hornlike process on the aedeagus of *falsa* is strongly angled or toothed, but this process is nearly evenly rounded in *nogales*. I have examined representatives of *nogales* only from Nogales, the Huachuca Mountains and the Santa Rita Mountains in Arizona.

Phyllophaga (Listrochelus) eligia n. sp.

MALE. Length 14.5 mm.; width 7 mm. Color brownish yellow, pronotum a little paler than elytra; disc of elytra, pronotum, and head shining, glabrous, a few short nearly erect hairs on ridge above each eye. Antenna ten-segmented, three-segmented club 1.3 times longer than combined length of six preceding segments, 1.6 times longer than clypeal length at middle. Clypeus 2.4 times wider at base than median length, sides straight and convergent, anterior margin straight, strongly reflexed in anterior one third; surface of clypeus and front smooth, with punctures generally irregularly spaced, some separated by distances equal to about four times their diameters, punctures more closely placed at sides of head; vertex conspicuously angled but not forming a carinate ridge, a few punctures behind ridge, especially on sides. Pronotum about 1.62 times wider than long, widest at middle, posterior angles strongly rounded, lateral margins broadly, not deeply crenulate, with about ten long mesally directed hairs arising from punctures between crenulations; discal punctures a little smaller than those on head and about as closely placed; narrow median longitudinal area almost without punctures. Elytra as finely but more evenly punctured than pronotum, punctures separated by about three times their diameters; discal costae vague. Pygidium very strongly convex, almost impunctate, surface glabrous except for a few short hairs near the subtruncate apex. Abdomen broadly and very shallowly depressed, nearly devoid of punctures except on sides and adjacent to posterior margins of sternite, these punctures with stiff hairs of varying lengths; last sternite about one half length of penultimate sternite, shallowly and narrowly longitudinally depressed at middle, depressions widening posteriorly with sides rounded to posterior margin of outer sclerotized surface of segment; last two segments with many semi-erect long coarse hairs especially near posterior margins. Metasternum finely and closely punctured, thickly covered with long hairs, two to three times longer than greatest width of middle femur. Anterior tibia with outer swelling toward base distinct but short; tarsal segments not produced on inner margins at apexes, each segment, except first posterior,

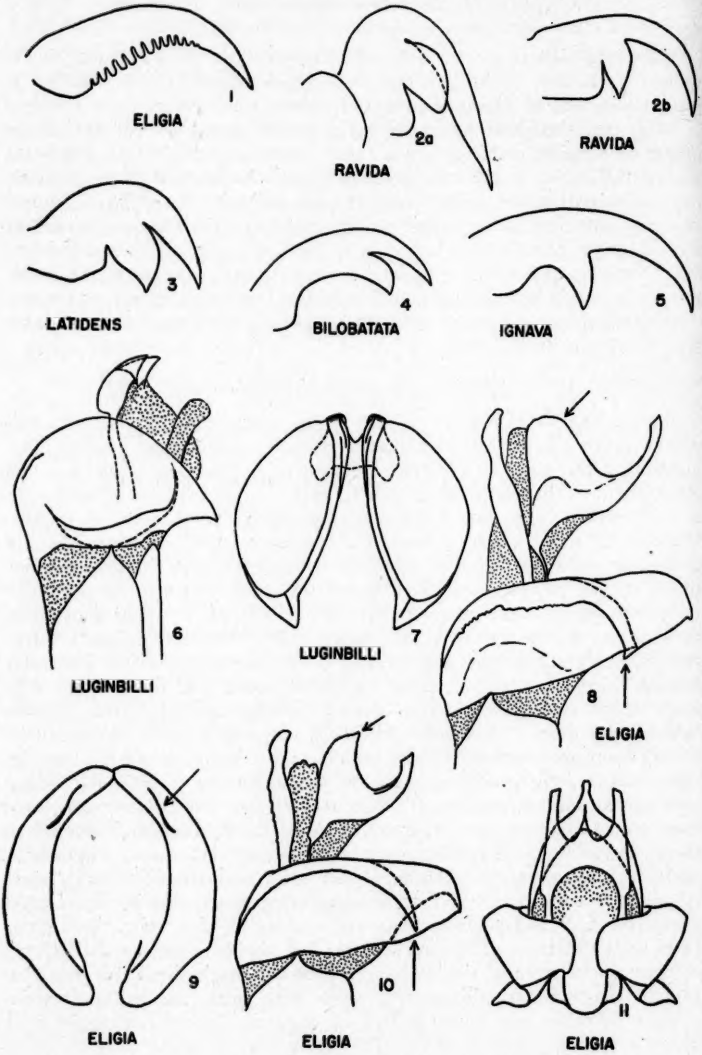

PLATE I

Fig. 1. *Phyllophaga eligia* n. sp. Male, tarsal claw of left front leg. Fig. 2a. *P. ravida* Blanch. Male, outer tarsal claw of left middle leg; 2b. Inner claw of same leg. Fig. 3. *P. latidens* Schffr. Male, outer tarsal claw of left middle leg. Fig. 4. *P. bilobatata* Saylor.

with a fine carina extending total length of lower margin, first posterior segment with short and inconspicuous carina; each tarsal claw (fig. 1) conspicuously pectinate below on a single margin and without intercalated larger and longer tooth, number of pectinations varying from ten to thirteen, one or more pectinations often closely joined; posterior tibial spurs jointed, slender, the longer spur much longer than first posterior tarsal segment measured from apex to basal constriction; apexes of posterior tibiae each with fourteen and sixteen spinules. Genitalia (fig. 8) with each paramere deeply excavated on side toward blunt apex, parameres narrowly joined at their bases (fig. 9), well separated at apexes; aedeagus (figs. 8, 10, 11) bearing four flat vertical lobes; thin lateral margins of parameres with many very fine uneven teeth.

FEMALE. Length 12-12.5 mm. Similar to male in most features except as follows: antennal club a little shorter than funicle or clypeus at middle; pygidium much less convex; abdomen evenly convex, last sternite unmodified; anterior tibia with short but distinct upper tooth or swelling; each tarsal claw bearing a short tooth beyond middle, the margin behind tooth distinctly pectinate; apexes of posterior tibiae each with sixteen to eighteen spinules.

Holotype male, Mojarachic, Chihuahua, Mexico, 6900 ft., 1938, I. Knobloch; paratype male, Montezuma Pass, Huachuca Mts., Arizona, July 11, 1957, G. D. Butler, on *Juniperus;* paratype female, same data; paratype female, west slope Patagonia Mts., Santa Cruz Co., Ariz., August 9, 1955, G. D. Butler and F. G. Werner, on *Juniperus pachyphloea.* Type in collection of United States National Museum, paratypes in collections of Illinois Natural History Survey and University of Arizona.

Variation. The fifth and sixth antennal segments of the female from the Huachuca Mountains are fused on one side; all other individuals have these segments distinct and the antenna is believed to be normally ten-segmented for the species. The paratype male is distinctly smaller than the type, measuring 12.5 mm. in length and 6 mm. in width. It differs also by having the antennal club 1.8 times longer than clypeal length at middle, clypeus 2.3 times wider at base than median length, pronotum 1.4 times wider than median length, last abdominal sternite more deeply grooved, one anterior tibia with outer swelling toward base nearly absent, first posterior tarsal segments without carinae, and posterior tibiae each with fifteen apical marginal spinules. Several differences occur in the male genitalia between the type and paratype, the lateral margins of each paramere of the paratype (fig. 10, see arrow) being much less angulate than in the type (fig. 8), the dorsal margin of paramere near base (fig. 9, see arrow) with a short ridge, each lateral sclerotized lobe of aedeagus (fig. 10) strongly angulate.

Female, tarsal claw of left front leg. Fig. 5. *P. ignava* Horn. Male, tarsal claw of left front leg. Fig. 6. *P. luginbilli* Saylor. Male genitalia, left lateral view. Fig. 7. *P. luginbilli* Saylor. Male genitalia, caudal view. Fig. 8. *P. eligia* n. sp. Male genitalia of type, left lateral view. Fig. 9. *P. eligia* n. sp. Male genitalia of paratype, caudal view. Fig. 10. *P. eligia* n. sp. Male genitalia of paratype, left lateral view. Fig. 11. *P. eligia* n. sp. Male genitalia of paratype, ventral view.

The pectinate tarsal claws (fig. 1), the presence of one marginal series of pectinations on the claw, the presence of a distinct transverse ridge on the vertex of the head, and the symmetrical male genitalia place this species in the subgenus *Listrochelus* and in the *cavata* complex which includes the Mexican or United States *laportaei* Blanchard (1850), *cavata* Bates (1888), *micros* Bates (1888), *meadei* Saylor (1940), *cochisa* Saylor (1940), and *planeta* Reinhard (1950). From these species the male of *eligia* may be distinguished by the four-lobed aedeagus and the peculiarly excavated lateral surface of the paramere. The female differs from females of other species of this complex by the simple unmodified last abdominal sternite and pygidium.

SUBGENUS *Phyllophaga*

Cribrosa group

This group of seven described species, usually black and crepuscular, is based on *cribrosa* LeConte found in New Mexico, Texas, and Oklahoma. Other species occur in the Southwest and Northern Mexico. Crepuscular species have very short metasterna with corresponding reduction of metathoracic wings. In all species examined the parameres are joined at their apexes (see illustrations of *cribrosa* by Luginbill and Painter, 1953) forming an angulate lobe. Females of a small black species have been examined in the University of Kansas collection from Flagstaff, Arizona, collected July 8, 1941 by Burt Hodgden. These have been tentatively identified as the Texas *epigaea* Wickham (1903) pending a revision of the group.

Ravida group

P. ravida Blanchard (1850) and *dentex* Bates (1888), widely distributed in Mexico, are the only representatives of this group found in the United States, and both occur in Arizona. Nearly a dozen species belong to the group which is distributed northward from Central America. *P. ravida* and *dentex* were treated by Luginbill and Painter (1953), each in a different section of the genus although their close relationship was noted. In addition to the male claw characteristics described in the key to groups, the parameres of the male genitalia are joined at their apexes somewhat as in the *cribrosa* group.

Phyllophaga ravida Blanchard

Ancylonycha ravida Blanchard 1850:136.
Lachnosterna heterodoxa Horn 1887:289. New synonymy.

Phyllophaga ravida is widely distributed in Mexico and Central America, and in the United States it has been taken at Nogales, Arizona, and Laredo, Texas (Sanderson, 1942). Horn described *heterodoxa* from both sexes stating that his representatives were collected in southern Arizona or possibly in Chihuahua, Mexico. His species was distinguished from *ravida* by its less robust shape, less corsely punctured body, and more shining dorsum. The species is variable in all these features, and an examination of the type of *heterodoxa* and many specimens of *ravida* from Mexico indicates this synonymy. Luginbill and Painter (1953) considered this species under the name *heterodoxa*.

Multipora group

The *multipora* group, of which the Mexican *multipora* Bates (1888) is a typical representative, contains about twenty species distributed from South America to Mexico. In addition to the key characters for recognizing members of this group, the dorsum generally is hairy, and the parameres of the male genitalia are joined at their apexes, the ventral part of the parameres usually with one or two pairs of teeth or angulations. *P. rossi* Saylor, described from Patagonia, Arizona, is the only known United States representative of the group. Although closely resembling small individuals of *lenis* Horn (*anodentata* group), *rossi* may be distinguished by having nine instead of ten antennal segments, and it does not have the bilobed process on the last abdominal sternite of the male as in *lenis*. The photograph of the male genitalia by Luginbill and Painter is unsatisfactory for the recognition of this species, but the illustrations by Saylor (1939) are adequate.

Anodentata group

Nearly twenty-five species belong to this group, which ranges from South America into the southern United States. The Central American and Mexican *anodentata* Bates (1888) is a characteristic member. The anterior margin of the last abdominal sternite of the male is elevated and bears a distinct emargination or a flat bilobed process near the crest, this process generally extending toward the posterior margin of the sternite. In some species, the posterior margin of the fifth sternite is slightly lobed at the middle and is closely adpressed to the elevated anterior margin of the last sternite. The male genitalia are similar to those of many species in the *setidorsis* group, having the parameres joined at their apexes and bearing one or two pairs of short lobes. Three species of the group range from Mexico into the Southwest, all occurring in Arizona. Two species, *lenis* Horn and *vetula* Horn, were discussed by Luginbill and Painter. A third species, *setifera* Burmeister, is an addition to the known *Phyllophaga* fauna of the United States.

Key to Arizona species of the *anodentata* group

Males

1. Width of head between eyes approximately 6 or 7 times wider than each eye; anterior margin of clypeus slightly emarginate ..... *vetula* Horn
   Width of head between eyes 2½ to 3½ times wider than each eye; anterior margin of clypeus rounded 2
2. Anterior margin of last abdominal sternite of male strongly reflexed posteriorly and bearing two closely placed flattened lobes produced to about middle of sternite; upper margin of joined parameres evenly rounded above paired ventral teeth (pl. 19, fig. 4, Luginbill and Painter, 1953) ..... *lenis* Horn
   Anterior margin of last abdominal sternite strongly raised, carinate, and finely notched but not produced caudad at middle; upper margin of joined parameres (fig. 20) strongly toothed on each side ..... *setifera* Burmeister

Phyllophaga setifera Burmeister

Ancylonycha setifera Burmeister 1855:335.
Lachnosterna setifera Burmeister. Bates 1888:198.

This species was described from Mexico and subsequently recorded by Bates from Panama, Guatemala, British Honduras, Veracruz, and Oaxaca. G. D. Butler collected a male on *Acacia* in Sabino Canyon, Tucson, Arizona, July 25, 1955, a new record for the United States. *P. setifera* is the same size as *vetula* and resembles a rubbed individual of that species by not having the long hairs near the base and apex of the elytron as in well preserved *vetula*. The male genitalia of the last two species have the same general pattern in which there are two pairs of ventral and dorsal processes on the parameres, but these two sets of processes are more widely separated in *setifera* (fig. 20).

Blanchardi group

Three of this extensive group of some fifty species, characterized by the Mexican *blanchardi* Arrow (1933), occur in Arizona; *gravidula* Moser (see Sanderson, 1937, under *perita* Sanderson), *latidens* Schffr., and *beckeri* Moser. These three species were treated by Luginbill and Painter, the latter under the name *inopia* Sanderson. The male abdomen of members of this group usually is strongly convex, the last one or two sternites sloping upward. The parameres generally are separated at their apexes, and many species have variously shaped processes or lobes arising from the upper margins.

Phyllophaga beckeri Moser

Lachnosterna beckeri Moser 1921:248.
Phyllophaga inopia Sanderson 1942:51. New synonymy.

An examination of the type male and several paratypes of *beckeri* Moser indicates this synonymy. *P. inopia* was described from the Chiricahua and Huachuca Mountains in Arizona, and *beckeri* from Promontorio, Mexico, without indication of the state. The locality, Promontorio, occurs in Sonora, Chihuahua, and Durango, and representatives of *beckeri* have been examined from the latter two states. Moser did not relate or illustrate his species, and it was not possible to identify *beckeri* until the type was studied.

Obsoleta group

The group is a heterogeneous one and as here restricted includes about twenty Mexican and Central American species, and possibly others from South America. The group is typified by *obsoleta* Blanchard, the only species of *Phyllophaga* known having a distribution range from South America to the United States. *P. pallida* Horn, *sonora* Saylor, *bilobatata* Saylor, and *obsoleta* Blanchard occur in the United States as well as in Mexico. The first three are found in Arizona. Saylor (1939) included these three species, also *trichodes* Bates (*sandersonia* Saylor), *georgiana* Horn, and *omani* Sanderson, in the no longer recognized subgenus *Phytalus*. I am excluding these last three species from the *obsoleta* group because, unlike *obsoleta* and allies, one of the two apical spurs of the posterior tibia of the male is rigidly joined to the tibia. From the *Chlaenobia* section of the genus (Chapin, 1935) I would also transfer to the *obsoleta* group those species

having a ten-segmented antenna. The *obsoleta* group as now limited, although not necessarily on phyletic grounds, includes species having the following combination of male characters: both spurs of the posterior tibia jointed; antenna ten-segmented, club shorter than stem; each tarsal claw cleft (fig. 4), the claws generally similar on all legs and rarely with very fine denticles on lower margins of lower tooth of each claw. The male genitalia are extremely variable, representing many subgroups and complexes.

Blanda complex of the *Obsoleta* group

Within the *obsoleta* group as defined here is a complex of three undescribed species distinguished collectively by the pruinose dorsum, few to many conspicuous hairs on at least the head, and a very short last abdominal sternite, measuring less than half the length of penultimate sternite; tibial spurs not strongly curved; clypeus distinctly emarginate; pygidium of female slightly convex. One of the species is described from Arizona, the other two from Guerrero and Nayarit in Mexico. In addition to differences in the genital parameres, these species also exhibit some remarkable developments in their aedeagi. In each individual studied the aedeagus was found to be invaginated in the basal piece of the genitalia. In order to examine these structures in dried specimens, it is necessary to clear the genitalia in KOH and to evaginate the aedeagus by manipulation with a blunt pointed, hooked pin. The aedeagus of a freshly collected specimen no doubt could be inflated using the method described by Sanderson (1939), but the incompletely extended structures illustrated in the present report probably show most of the useful taxonomic features of these three species.

Key to species of the *Blanda* complex

1. Pygidium shining; dorsum with extremely minute hairs, these confined to the very small but widely separated elytral punctures, and to a small area next to each eye; parameres not fused at apexes, each pointed (figs. 12, 16), and without a transverse ridge ..... *blanda* n. sp.

   Pygidium almost entirely pruinose, shining only at extreme apex; dorsum with conspicuous hairs, these sometimes restricted to the anterior pronotal region; parameres (figs. 17, 18) lightly fused at apexes, each blunt apex having a transverse ridge (figs. 13, 14) 2

2. Elytra with short but distinct semi-erect hairs in addition to some long coarse hairs near scutellum; pronotum with some long erect coarse hairs on disc in addition to coarse hairs near anterior margin 3

   Elytra with very minute hairs, these almost all confined to the punctures, at most a few longer and coarser hairs at elytral base; coarser hairs on pronotum confined to a band behind anterior margin; upper margin of paramere (fig. 13) nearly evenly convex ..... *epulara* n. sp.

3. Long basal elytral hairs distinctly longer than greatest width of scutellum; upper margin of paramere (fig. 13) nearly evenly convex ..... *epulara* n. sp.

   Long basal elytral hairs shorter than scutellar width; upper margin of paramere (fig. 14) broadly concave before apex ..... *beameri* n. sp.

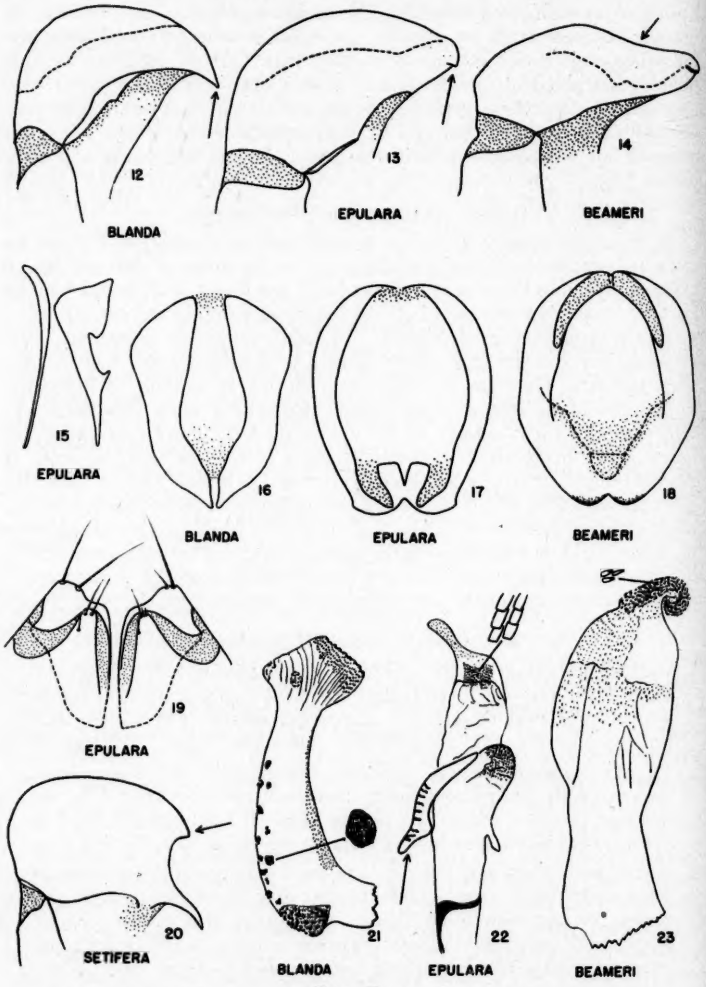

PLATE II

Fig. 12. *Phyllophaga blanda* n. sp. Male genitalia, left lateral view. Fig. 13. *P. epulara* n. sp. Male genitalia, left lateral view. Fig. 14. *P. beameri* n. sp. Male genitalia, left lateral view. Fig. 15. *P. epulara* n. sp. Female anal plates. Fig. 16. *P. blanda* n. sp. Male genitalia, caudal view. Fig. 17. *P. epulara* n. sp. Male genitalia, caudal view. Fig. 18. *P. beameri* n. sp. Male genitalia, caudal view. Fig. 19. *P. epulara* n. sp. Female genitalia. Fig. 20. *P. setifera* Burm. Male genitalia, left lateral view. Fig. 21. *P. blanda* n. sp. Male genitalia, aedeagus. Fig. 22. *P. epulara* n. sp. Male genitalia, aedeagus. Fig. 23. *P. beameri* n. sp. Male genitalia, aedeagus.

Phyllophaga blanda n. sp.

MALE. Length 18 mm.; width 9 mm. Color of elytra buffy brown, head and pronotum dark brownish red, head darker than pronotum; pronotum and elytra pruinose, essentially glabrous, a few very short pronotal hairs on sides seen at magnification of 20×, and a few longer hairs near each eye. Antenna ten-segmented, the three-segmented club exactly equal in length to stem, and approximately twice length of clypeus at middle. Clypeus narrowed and rounded, distinctly but not deeply emarginate at middle, the front margin very narrowly and inconspicuously reflexed; surface moderately finely and closely but not confluently punctured; punctures of front more irregular in size, some of them larger than clypeal punctures, more irregularly spaced. Pronotum 1.8 times wider than median length; side margins behind middle straight but slightly divergent, very slightly crenulate, the posterior angles rectangular; side margins in front of middle straight, strongly convergent, with two or three seta-bearing indentations; punctures finer than those on head, slightly irregularly distributed, separated by distances averaging two to four times their diameters. Elytra as finely punctured as pronotum, the surface somewhat irregular and with one or two very vague costae. Pygidium moderately convex, more strongly so near apex, about one fifth wider than long, surface glabrous, shining, the punctures small, somewhat obscure, separated approximately by their own diameters. Abdomen flattened and shining at middle throughout its length, slightly concave, with minute depressed hairs on sides, fifth sternite essentially unpunctured and unmodified, last sternite about one third length of fifth, convex in anterior half, narrowly transversely grooved in posterior half. Metasternum finely and moderately closely punctured, thickly covered with hairs approximately equal in length to greatest width of middle femur. Anterior tibia tridentate, each of first four anterior tarsal segments acutely produced on inner margin at apex, the point on first segment less than half apical width of segment; all tarsal claws of same shape, cleft, upper tooth slightly longer than lower, lower tooth slightly wider than upper; both posterior tibial spurs jointed, slender, the longer spur four fifths length of first posterior tarsal segment measured from apical margin of segment to subbasal constriction; apexes of posterior tibiae with seventeen and eighteen spinules. Parameres of genitalia narrowly separated at bases and apexes (fig. 16); upper margin (fig. 12) evenly convex, apex of each paramere pointed; aedeagus (fig. 21) with an elongate irregular group of small spine clusters on membrane, with a heavily sclerotized lobe at the base of the group bearing numerous small spines.

Holotype male, Sycamore Canyon near Ruby, Arizona, Santa Cruz County, August 10, 1955, F. G. Werner and G. D. Butler, at light; paratype male, Nogales, Arizona, July 30, 1957, D. J. and J. N. Knull. Type in collection of the Illinois Natural History Survey, paratype in Ohio State University collection.

Phyllophaga epulara n. sp.

MALE. Length 18 mm.; width 9 mm. Color of elytra buffy brown, pronotum dark brownish red, head darker; pronotum, elytra and pygidium

pruinose. Antenna ten-segmented, the three-segmented club slightly shorter than combined length of six preceding segments, slightly longer than length of clypeus at middle. Clypeus narrowed and rounded, conspicuously emarginate, the front margin very narrowly reflexed; surface with moderate punctures separated from one half to their own diameters; some punctures on front larger than those on clypeus, generally more closely spaced except near clypeo-frontal suture; front with a few hairs, some nearly one half median length of clypeus. Pronotum 1.8 times wider than median length; side margins slightly divergent toward base but nearly evenly rounded from base to apex and with about a dozen crenulations; posterior angles almost rectangular, anterior angles not produced; discal punctures finer and shallower than those on head, separated by distances of one to four times their diameters but averaging about twice; each puncture with a short depressed hair, some hairs fully twice as long as width of puncture; in addition to these small punctures about twenty-five larger punctures in anterior one fourth of pronotum, each bearing a very coarse seta some of which are one third median pronotal length. Elytra more finely punctured than pronotum, punctures not closely placed, each with a minute depressed hair about equal in length to small pronotal hairs; also a few longer but depressed hairs close to anterior margin of elytron; disc of elytron with one vague costa; apex of each elytron slightly emarginate. Pygidium moderately and evenly convex, very finely punctured, some punctures separated by five times their widths, each with a very short, depressed hair. Abdomen very slightly convex at middle, glabrous at middle, evenly pruinose, fifth sternite unmodified, last sternite about one third length of fifth, transversely grooved at middle. Metasternum finely punctured, thickly covered with short hairs, some nearly equal in length to greatest width of middle femur. Anterior tibia tridentate, first two tarsal segments with very inconspicuous internally produced apexes; all tarsal claws of same shape, cleft, upper and lower teeth of equal length and approximately equal width; both posterior tibial spurs jointed, slender, the larger slightly longer than first posterior tarsal segment; apexes of posterior tibiae with nineteen and twenty-two spinules. Parameres of genitalia weakly joined at bases (fig. 17), distinctly joined at apexes; upper margin (fig. 13) nearly evenly convex, apex of each paramere with transverse ridge; aedeagus (fig. 22) bearing conspicuous footlike lobe; apical region of aedeagus with many small imbricated spines.

Holotype male, Acahuizotla, Guerrero, Mexico, 3800 ft., June 7, 1952, C. M. Rowell; paratype male, Acapulco, Guerrero, Mexico, July 1, 1951, P. D. Hurd (UC). Type in collection of Illinois Natural History Survey, paratype in collection of University of California. Two additional individuals which possibly represent this species bear the following data: male, Tamazula, Jalisco, Mexico, July 10, 1957, R. & K. Dreisbach; paratype female, Mazamitla, Michoacan, Mexico, July 24, 1953, D. Rockefeller Mex. Exp. 1953, C. & P. Vaurie (AMNH). Each differs strikingly from the type and paratype male by having, in addition to many short depressed evenly distributed dorsal hairs, several long erect hairs on the pronotal disc, in the scutellar region of the elytra, on the apical elytral declivity, and near the lateral margin of each elytron. The genitalia of the male from Tamazula

is like that of the type in all respects. The pygidium of the female is slightly convex, uniformly pruinose except for a shining spot at apical one third, and very finely but not closely punctured, each puncture bearing a short semi-erect hair. Female genitalia (fig. 19); femal anal plates (fig. 15).

Phyllophaga beameri n. sp.

MALE. Length 16.5 mm.; width 8.5 mm. Color of elytra buffy brown, head and pronotum dark reddish brown, head darker than pronotum; pronotum, elytra, and pygidium predominantly pruinose. Antenna ten-segmented, three-segmented club 1.3 times longer than combined length of six preceding segments, about 1.6 times longer than clypeus at middle. Clypeus narrowed and rounded to front margin which is conspicuously emarginate, the margin very narrowly reflexed; surface with moderate punctures separated by about one half their diameters, a little more widely spaced at middle near suture; punctures each with a short erect hair, the longest about one third length of clypeus at middle; punctures on front of same size as those on clypeus and slightly more closely placed, each having a short semi-erect hair to a long erect hair, the latter conspicuously longer and coarser than those on clypeus, some hairs three fourths median length of clypeus. Pronotum 1.7 times wider than long, slightly widest at middle, nearly evenly convex from the almost rectangular base to the unproduced apical angle; margin finely crenulate, especially in basal half and with about fifteen marginal setae; discal punctures a little finer and shallower than those on head, separated by distances from one to three times their diameters, averaging nearly twice; each of most punctures with a moderately long subdepressed hair, the longest about one tenth median pronotal length; in addition to these hairs, many irregularly longer, coarser, and darker hairs arising behind the anterior magin and on the sides, the longest of these hairs one fourth median pronotal length. Elytra a little more finely punctured than pronotum, the punctures separated by twice their diameters, each puncture bearing a distinct but short semi-erect hair, also a few long coarse setae in basal and apical regions of elytra; a single vague costa on disc; apex of each elytron straight or nearly so, not at all emarginate. Pygidium very slightly convex, finely but distantly punctured, each puncture with a short erect hair, hairs variable in length; apex of pygidium glabrous. Abdomen evenly but not strongly convex, pruinose, but not closely punctured, each puncture with a short semi-erect, curved hair, fifth sternite unmodified, last sternite almost one half length of fifth, transversely grooved in posterior one half. Metasternum finely and moderately closely punctured, thickly covered with hairs some of which are nearly equal in length to greatest width of middle femur. Anterior tibia tridentate, each of first three anterior tarsal segments slightly produced at apex on inner margin; all tarsal claws of same shape, cleft, upper and lower teeth of equal length, the lower distinctly wider at base than upper; posterior tibail spurs jointed, rather broad toward base, the longer equal in length to first posterior tarsal segment; apexes of posterior tibiae with twenty-five and twenty-six spinules. Parameres of genitalia (fig. 18) weakly united basally, more broadly joined at apexes; upper margin (fig. 14) slightly but broadly emarginate; apex of each paramere with transverse ridge; aedeagus as in fig. 23.

Holotype male, 16 miles NW Tepic, Nayarit, Mexico, July 19, 1953, University of Kansas Mexican Expedition. Type in collection of University of Kansas. This species is dedicated to the memory of Dr. R. H. Beamer, my companion on many May beetle collecting trips.

Setidorsis group

This is one of the largest groups of New World *Phyllophaga* containing about sixty species of which one third are known to occur in the United States. Other members of the group, including the characteristic Mexican *setidorsis* Bates (1888), are distributed through Mexico, Central and South America. The only Arizona representative is *inflexa* Barrett, which, unlike most Arizona *Phyllophaga,* appears to be more closely related to several eastern species than to the Mexican elements. It was treated by Luginbill and Painter (1953). Several types of male genitalia are found in this group, but in nearly all species the parameres are joined at their apexes; many species have one or two pairs of teeth on the ventral side as in the *anodentata* group.

Ignava group

The *ignava* group in Arizona, in addition to *ignava* Horn, includes *lobata* Fall, *fucata* Horn, and *opaca* Moser (*iroides* Fall), all occurring in Mexico. These four species were treated by Luginbill and Painter (1953) in two "classes". In addition to these species, nine or ten others occur in Texas and New Mexico, and about fifteen species have been recognized principally from Mexico and Central America.

Phyllophaga opaca Moser

Lachnosterna opaca Moser 1918:165.
Phyllophaga iroides Fall 1929:112. New synonymy.

P. iroides, described from the Huachuca Mountains in Arizona, was compared with *submucida* LeConte, a southern species not known to occur in Arizona. *P. opaca* was described from Mexico without additional information and it was not compared with other species. The types of both species have been examined and are identical in all respects. The species was treated by Luginbill and Painter (1953) under the name *iroides.*

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THE GENUS *BONZIA* IN THE NEW WORLD (Acarina, Cunaxidae)[1]

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The new world species described below is intermediate between *Cunaxa* v. Heyden, 1826 and *Bonzia* Oudemans, 1927. *Bonzia,* as defined for the two European species, *B. halacaroides* Oudem., 1927 and *B. sphagnicola* Willmann, 1939, is characterized by Thor and Willmann (1941) and Baker and Hoffman (1948) as having a many-branched spine on the dorsomedial surface of the third palpal segment (telofemur), palpi shorter than the chelicerae, a pair of geniculate setae on the anterolateral margins of the hypostome (fig. 2), one pair of eyes, and the leg coxae fused with the venter of the podosoma to form one large ventral plate. However, this new species possesses only one of the above characters, the branched spine on the palpal telofemur, while the other features mentioned above are as in other genera, especially *Cunaxa.* Only the branched spine on the palpal telofemur now appears to be a unique structure for *Bonzia.* Considering the characters of this New World species and those of the two Old World species, it appears desirable to redefine the genus *Bonzia.*

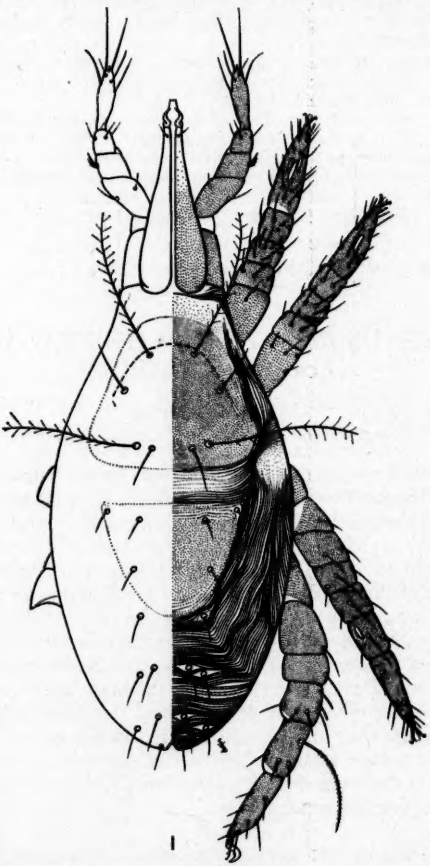
[1] Contribution number 965 from the Department of Entomology, University of Kansas.

Genus *Bonzia* Oudemans

Similar to *Cunaxa* but with a many-branched spine located dorsomedially on third palpal segment (telofemur) and/or one pair of large geniculate setae on anterolateral angles of hypostome; palpi five-segmented, approximately equal in length to chelicerae; leg coxae and venter of podosoma may fuse to form a single plate; one pair or no eyes present; two dorsal shields; prominent apodeme connecting anterior sensilla bases; tarsal apices without lateral extensions.

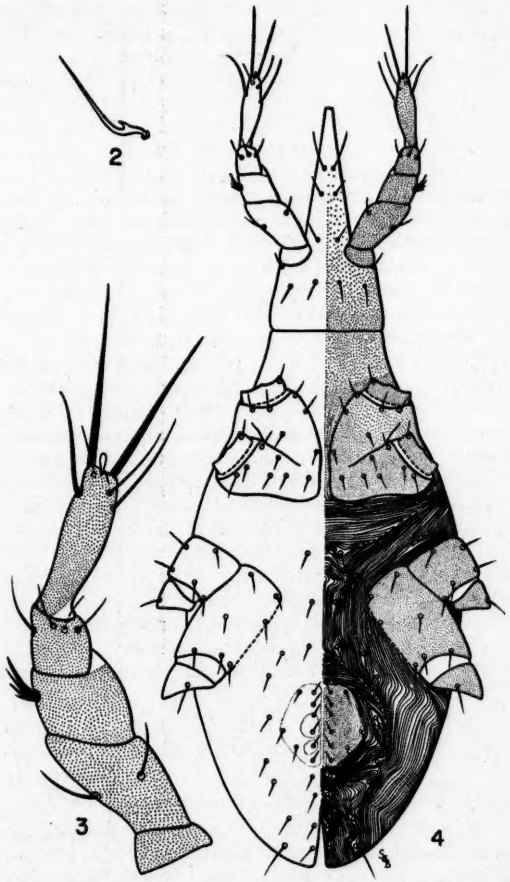
Bonzia bdelliformis n. sp.

FEMALE. Color in life, dark brown. Body narrowly oval, including gnathosoma, 383 μ in length; broadest at coxae III. Dorsum of podosoma



Bonzia bdelliformis. Fig. 1, dorsal aspect of holotype.

bearing two finely granulated plates; anterior plate rectangular to trapezoidal, bearing two pairs of tactile setae and two pairs of sensilla; posterior plate semicircular bearing three pairs of setae; punctations of plates merge into fine body striae; eyes wanting. Venter of podosoma finely striated except in regions of the coxae and genital areas. *Gnathosoma:* conical, projecting prominently from idiosoma, integument finely granulated. Chelicerae attenuate (110 μ in length), broadest at base (20 μ); fixed digit wanting; movable digit small, sickle-shaped; one small seta located lateromedially



Bonzia sp. Fig. 2, geniculate seta. *B. bdelliformis.* Fig. 3, lateral aspect of right palpus; fig. 4, ventral aspect of holotype.

near base of blade. Hypostome base rectangular (51 μ wide), distal portion broadly attenuate, base with four pairs of small setae (7 μ long), distal portion with two pairs of setae, proximal pair 14 μ in length, distal pair 27 μ. Palpus short, thick, gently bent (in life the convexity is dorsal), extending slightly beyond tips of chelicerae, five-segmented; lengths of segments: trochanter, 14 μ; basifemur, 27 μ; telofemur, 19 μ; genu, 13 μ; tibiotarsus, 34 μ. Chaetotaxy of palpus: trochanter, nude; basifemur with one seta dorsomedially, one subequal seta lateromedially; telofemur with a many-branched spine dorsomedially; genu with four subequal setae arranged in a single band around segment; tibiotarsus with one strong, sigmoid-shaped seta dorsomedially near apex (27 μ long), two subequal setae ventromedially near apex, one fine seta lateromedially near apex, one bulbous, hollow, sensory seta arising lateromedially immediately behind insertions of terminal setae, two strong acuminate, terminal setae situated on apex, the dorsal seta 43 μ in length, ventral seta 36 μ. *Idiosoma:* two pairs of normal setae and two pairs of finely branched sensilla on anterior plate. Anterior pair of sensilla 92 μ in length, posterior pair 84 μ in length, the distance between anterior sensilla bases 23 μ, distance between posterior sensilla bases 41 μ. Posterior plate with three pairs of setae arranged in two transverse rows, anterior row with four setae, posterior with two setae; arrangement of remaining setae as in fig. 1. Ventral chaetotaxy as in fig. 4. *Legs:* legs I and II directed forward, legs III and IV directed to the rear; 7-segmented, including coxae; coxae I-II and III-IV form confluent groups delineated by apodemes and finely punctate plates; lengths of legs excluding coxae: I, 151 μ; II, 141 μ; III, 152 μ; IV, 160 μ; lengths of segments of leg I: trochanter, 12 μ; basifemur, 34 μ; telofemur, 15 μ; genu, 17 μ; tibia, 18 μ; tarsus, 56 μ. Two simple claws; empodium reduced to small plate with four prominent rays. Chaetotaxy of legs: nude, acuminate, tactile setae and attenuate, bluntly tipped, apically slightly curvate, hollow sensory setae arranged as in fig. 1. Hollow, thin-walled, conical setae with constricted bases on dorsal surfaces occurring as follows: tarsus I, three, large, central, arranged in oblique triangle; tibia I, two, small, medial; tarsus II, one, large, central; tibia III, one, small, near proximal end. Tibia IV with dorsal branched trichoboth (long sensory seta) 58 μ in length located centromedially in large socket. *Genital area:* aperture 43 μ long; two finely granulated, lateral plates each bearing nine small, nude setae, of which six are arranged in a longitudinal row, three around periphery (fig. 4); one pair of setae within aperture at posterior end; two pairs of subequal genital suckers.

MALE. Unknown.

Holotype: female, Roane Co., Tenn., AEC Controlled Area, near Oak Ridge, October, 1956, S. Auerbach, D. A. Crossley, Jr., beech treehole (Berlese).

Paratypes: 23 females, same data as holotype.

Location of types: holotype and 19 paratypes deposited in the Snow Entomological Museum, University of Kansas, Lawrence, Kansas. One paratype at each of the following: Ecology Group, Health Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee; United States National Museum, Washington 25, D.C.; British Museum (Natural History), Lon-

don, S.W. 7, England; South Australian Museum, Adelaide, South Australia.

This species is easily distinguished from the other described species of *Bonzia* by the absence of the geniculate setae, the large ventral plate, and the eyes. It is possible that *B. bdelliformis* is an aberrant *Cunaxa,* but at the present time it does not seem advisable to reevaluate the genera of the family Cunaxidae.

In life *B. bdelliformis* closely resembles Mesostigmata nymphs, and as a result could be easily overlooked in sorting miscellaneous material. In slide preparations, the two end bristles at the apex of the palpus give this species a superficial resemblance to the family Bdellidae, hence the specific name.

The author would like to thank Mrs. Sylvia Barr for the preparation of the illustrations and Dr. S. I. Auerbach, Ecology Group, Health Physics Division, Oak Ridge National Laboratory, for the material used in this study.

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FIVE NEW SPECIES OF TABANIDAE (DIPTERA) FROM MEXICO AND BRAZIL

CORNELIUS B. PHILIP[1]

The present journal number, which memorializes the productive entomological career of Professor R. H. Beamer, presents an opportunity to publish descriptions of five tabanids dedicated to colleagues, including Professor Beamer, that have been held overlong for an appropriate outlet. Professor Beamer and his students have not only contributed in a remarkable way to a knowledge of the occurrence and distribution of Nearctic Tabanidae through their industrious summer collecting trips, but have generously provided access to the historically important Snow, Williston, and general Kansas collections, which are so indispensable to North American students of this family of flies and which include important Mexican species as well. A remarkable new species in the latter fauna is dedicated below to this fine entomologist and long-standing friend.

It may be pointed out that two species of tabanids have already been named in honor of Professor Beamer, i.e., *Chrysops beameri* Brennan and *Pilimas beameri* Philip which has since been considered a subspecies of *P. californica* (Bigot).

[1] U. S. Department of Health, Education, and Welfare, Public Health Service, National Institutes of Health, National Institute of Allergy and Infectious Diseases, Rocky Mountain Laboratory, Hamilton, Montana.

An anecdote is also appropriate here. Professor and Mrs. Beamer and two students "invaded" the Bitterroot Valley one summer on one of their collecting expeditions. Both Beamers and one student each captured specimens of *Stonemyia tranquilla fera* (Williston) in *incidental* collecting in a high mountain meadow which provided a new Montana record right in the writer's "backyard," so to speak, where he had been collecting tabanids for years. As incidental collectors in this family, they turned up some remarkable records over the years, such as several unusual flies later described as *Bequaertomyia anthracina* Brennan from Big Tree National (Giant) Forest in California. This is an offshoot of a primitive element known heretofore only in Chile and Australia—a group of flies which has since been set up in a family of its own.

The following five new Neotropical species are dedicated to colleagues who have provided much invaluable assistance during my studies of the Tabanidae.

Dichelacera (Psalidia) beameri n. sp.

A bright, orange-yellow-bodied species with concolorous appendages and yellow wings with contrasting dark pictures; the tips of both wings have been broken off. The antennal plates have hooks reaching to their tips, i.e., to the base of the first annulus.

Holotype male, 16.5 mm. Head wider than thorax; eyes bare, area of enlarged facets dull yellow, occupying upper three-fifths and rolled over occipital margin attenuating the band of smaller black facets about half way to vertex. No prominent margin of upright hairs, the tubercle at vertex ovoid, yellow, and with short yellow hairs at eye level. Entire body unicolorous bright orange without pattern, including all vestiture and appendages except for brown apical annuli, contrasting black labella, and dark tips of tibiae and tarsi which are also black haired; notum with yellow hairs, a few, inconspicuous, black hairs on tergites 2 to 4. Scapes about as long as tall, very little produced above, the annuli plainly shorter than the plate. Terminal palpal segment cylindrical, hardly twice as long as thick and with a slight, downward directed, blunt apical nipple. Theca yellow, a median plate in the black labella sclerotized and shiny. Abdomen rather elongate, suddenly tapered at last two segments. Wings, unfortunately, badly broken, yellow to tip of stigma and discal cell immediately beyond which the torn margins suggest either a contrasting blackish apex or crossband; anal lobes, tips of anal and cubital cells smoky. In complete specimens, it is anticipated that cell R_5 may be closed at the wing margin. Subepaulets bare.

The type specimen was collected at Jalostoc, Morales, Mexico, on June 5, 1951, by F. Pacheco M. and was studied through the courtesy of Dr. William Gibson of the Rockefeller Foundation in Mexico City. To be deposited in the U. S. National Museum.

The relationship to other species of *Psalidia* is so apparent that this can safely be assigned here in spite of the unfortunate missing wing tips. The bright orange color, lack of conspicuous dark hairs laterally on the abdomen, and annuli darker than plate distinguish this from other species of *Psalidia*.

Though Krober and others have considered *Psalidia* as a full genus, Fairchild and the writer will treat it as a subgenus of *Dichelacera* in a review in preparation.

Stenotabanus stonei n. sp.

A medium-sized, compact, dark brown species with a row of small pale triangles on the abdomen, spotted wings with spur veins, and bare subepaulets.

Holotype female, 9 mm. Eyes with short, dense hairs; no pattern evident on brief relaxing. Front with sides slightly divergent above, index 1:3.7, dark yellowish pollinose, an evanescent smoky patch surrounding an isolated, black line or callus in the middle, ocellar tubercle with three vestigial ocelli surrounded by a dark brown bare spot at the vertex which does not reach eye margins, basal callosity black, protuberant, subquadrate, occupying the full width of the lower front, the upper margin weakly tridentate but not connected with the median callus. Subcallus brownish red pollinose. Face and cheeks dark gray pollinose with sparse black hairs and a few yellow hairs. Antennae short and stubby, the scapes black with concolorous hairs, pedicels and base of plates dull reddish brown darkening distally onto the black chunky annuli which are hardly longer than the maximum width of the plates; the latter are about 1.5 times as long as wide, and neither excavated nor angulated dorsally. Palpi deep yellow, black-haired, rather slender, and tapered to a blunt point, the apical segment 3.6 times longer than thick.

Thorax black on notum, dark brown around margins and scutellum, worn but with evidence of sparse black and appressed yellow hairs. Pleura dark brown with black hairs. Coxae and femora brownish black with mostly black hairs; tibiae reddish with black hairs, the fore pair darkened apically. Wings distinctly tinted, the costal cells and stigma pale yellow; crossveins distinctly clouded, spur veins as long as their stems. Halteres brown, the knobs yellowish.

Abdomen rather thick and compact, deep brownish black with narrow reddish incisures which widen in the middle to form small, narrow, pale yellow-haired triangles, none of which quite crosses its respective tergite; indefinite reddish shadows sublaterally on the first three tergites; predominantly black haired. Venter blackish brown with a gray bloom and black hairs, the incisures reddish with some pale yellow hairs.

The type is labelled "Chiapas, Mexico, Mt. Ovando, 1900 m., Mar. 10, 1939, P. Brodkorb." In U. S. National Museum. The species is described through courtesy of Dr. Alan Stone for whom it is cordially named in gratitude for many past favors.

Fairchild (1953) has described two species of *Stenotabanus* from Chiapas which have the more slender build of the typical *taeniotes* group, while the present species has the more compact appearance of several flies described from Central and South America often with similar spotted wings. The abdomen of *S. stonei* is somewhat like *S. plenus* (Hine) from Guatemala and *S. marucci* Fairchild from Panama, but the last differs from *S. stonei* by a much narrower front and lined thorax, while *S. plenus* is a browner

insect without wing spots. The wing spots and form somewhat resemble *S. furvus* (Hine) from Bolivia, but the latter has a narrower front and no abdominal triangles. The type of *Stypommia maculipennis* Krober, also from Bolivia, was destroyed in Hamburg, but four paratypes seen at the British Museum agree with a homotype of *S. furvus* compared by me in 1953 (new synonymy). Fairchild (1956) also considered that Krober's (and hence Hine's) species is a synonym of *"Tabanus" venosus* Bigot from Brazil but has since decided (correspondence) that these two are distinct. Hine overlooked the ocelli but these alone are hardly sufficient in my opinion to maintain the genus *Stypommia,* certain assigned elements of which, including the genotype species, *T. tritus* Walker, belong in *Dasybasis,* while others, such as *venosus* and *furvus,* relate to *Stenotabanus.*

This is not the place to discuss these generic relationships, but a further complication may be noted that the probable, though long lost, type (and genotype) of *Agelanius meridianus* Rondani was discovered by Professor A. Goidanich of the University of Turin and received on loan through Professor Mario Salfi of the University of Naples. The specimen carries the label *"Agelanius meridianus* ♀ Chile" in what could be Rondani's hand writing. This proves to be an earlier name for the well-known *"Stypommia" anachoreta* (Philippi), a congener of *trita,* both of which are from Chile. This new information will not affect the position of *Stenotabanus stonei* n. sp.

Hybomitra beieri n. sp.

A rather small dark fly with brown abdomen and a median row of low pale triangles, the spotted wings inordinately long and abdomen small and attenuated; eyes sparsely hairy and a low bare tubercle at vertex but no ocelli.

Holotype female, 10 mm., wings 10 mm. Eyes (relaxed) entirely greenish without revived stripes; hairs hardly visible with a hand lens. Frontal index 1:4.7, parallel-sided, brown pollinose and pilose; basal callosity small, brown, separated from ocular margins and with a peculiar vertical median sulcus; extended above in a tall narrow median keel two thirds distance to vertex. Subcallus reddish brown pollinose. Face darker, grading into gray on cheeks. Beard short, straw yellow. Antennae long and narrow, reddish, a lateral dark streak on the plates connecting with the black annuli which are shorter than plates; latter a third longer than wide; dorso-basal teeth rectangulate, low but sharp; two basal segments black, scapes not swollen. Palpi pale brown, as long as antennae and very slender, blunt, almost three fourths length of proboscis.

Thorax with squared shoulders in front so that the head has a peculiar compacted appearance against it; notum and scutellum blackish, dull reddish on the antealar tubercles, no stripes; covered with brown and appressed metallic purplish vestiture. Pleura gray brown with pale yellowish hairs. Coxae deep brown with pale hairs. Femora and apices of tibiae deep brown, predominantly black-haired. Two hind pairs of tibiae mainly, and base of fore tibiae, reddish; hind-tibial fringe black. Wings smoky, costal cells yellow; prominent, accentuated clouds on the cross-veins and fork. Cell R_5 wide open, no spur veins. Subepaulets hairy.

Abdomen unusually small and narrowed behind, chocolate brown, darkening caudally. A median row of small, equilateral, pale yellowish triangles on all tergites, smallest on 1 and 6 which do not reach half way across each tergite; a median, dark, integumental spot in front of the triangle on 2. Incisures not pallid. Vestiture brown, except pale on triangles and outer hind corners. Venter unicolorous chocolate brown, entirely pale haired.

The type is labelled "Cantarera, b. São Paulo," "Bas. Exped. Wettstein. '91" "Therioplectes n. sp. det Bischof." In Vienna Natural History Museum. Named for Professor Dr. Max Beier, Curator of Insects in that museum, who has been most generous with favors in the past and with loans of historic material from the important collection in his charge.

Paratypes: Three females, same data (two in the collection of the author). In close agreement, including size and the peculiar compacted appearance, oversize wings, and small pointed abdomens. One is more reddish over-all, including legs and abdomen, especially the venter; it also has more yellow than black hairs on the palp, and the notal hairs have metallic greenish hues.

The species has some affinities with the larger *Poecilosoma obscuriventris* Krober from Bolivia which differs in swollen scapes, stronger toothed plates, hyaline (though spotted) wings which do not equal the body in length, and differently patterned abdomen.

Tabanus barrettoi n. sp.

A distinctive, rather small, slender, chocolate brown species with broad front, large callosity, plain vertex, reddish appendages, sparsely hairy subepaulets, lined thorax, and three rows of pale abdominal spots but no median triangle on tergite 2.

Holotype female, 9.5 mm. Eyes bare, two narrow green bands on a purple ground (relaxed). Front subparallel-sided, slightly bowed in the middle, index 1:2.6; buff pollinose above with short brown hairs, no ocelligerous tubercle; steel-gray pollinose on either side of short brown medial keel; the latter connected below to a large, dark brown, quadrate callosity which touches the eye margins. Subcallus shallow, buff pollinose. Face and cheeks creamy-gray pollinose and pilose. Antennae dark reddish with black hairs basally; scapes not swollen, plates almost as broad as long with a blunt dorsal angle and scarcely excavated; annuli slender, attenuated, subequal to plates in length. Palpi slightly enlarged basally, but little tapered to blunt apices, covered with short, coarse brown hairs; creamy hairs on the basal segments.

Thorax brown above with five prominent gray lines its full length; scutellum brown; covered with fine brown and appressed coppery hairs. Legs concolorous reddish with predominantly pale hairs, darker on the tips of the tibiae and tarsi. Hind-tibial fringe not prominent, with mostly blackish hairs. Halteres reddish. Wings hyaline, the costal cells faintly tinted. Cell R_5 wide open, a slight vestige of a short spur at base of vein R_4 of one wing.

Abdominal pattern characterized by a pale spot under scutellum on tergite 1; a pair of diagonal pale dashes sublaterally on tergite 2 resting on

hind margins and almost crossing tergite but no spot mesally; tergites 3 to 5 with large median triangles crossing the segments, and paired, small, isolated, pale spots sublaterally; tergites 6 and 7 dark brown without spots. Vestiture brown and pale in agreement with the integumental pattern. Venter reddish brown, with a broad dark brown pollinose, median, longitudinal band, the incisures narrowly pallid.

The type female was collected at Pernambuco, Brazil, by S. Gonzales, 1933, and presented to the British Museum (Natural History) by H. W. Kumm (BM 1933-503).

Paratypes: Four females, same data, in close agreement except the sublateral abdominal spots vary in prominence; three females, "Est. Ceará, Russas or Quiadá, Shannon Col., I. 940," (seen through courtesy of Dr. M. P. Barretto of São Paulo). In collections BMNH, CBP, and Barretto. Most specimens show no trace of spur veins at base of vein R_4. There is a tendency in a few for the frontal callosity to become drop-shaped, converging broadly into a point above, and narrowly separated from the ocular margins below. The frontal index may be as wide as 1:2.2. In well preserved specimens there is a quadrate, evanescent, brown patch of pollinosity about the size of the callosity in the middle third of the front which gives the appearance of denudation when viewed from in front, but which changes to gray to match the upper third when viewed from above.

This species has the slender, delicate build of a *Stenotabanus* and may well be an annectant form. I prefer, for the present, to leave it in *Tabanus* because of the lack of any vestige of a bare spot at the vertex (also true for most *Aegialomyia*) and because of the setose basicostas, even though these setae may be sparse in some specimens, a question also discussed by Fairchild (1942). The palpi are more slender and annuli more pointed than in most *Stenotabanus*.

The abdominal pattern is quite distinctive with its lack of a median triangle on tergite 2. The species is cordially dedicated to Dr. Barretto, who contributed part of the type series, and whose studies on Neotropical Tabanidae are well known.

Silvius gibsoni n. sp.
(Figure 1)

A dark gray slender species of the *quadrivittatus* group with tinted wings, pale brown costal cells and accentuated spots reduced in number, robust antennae, and frontal and facial calli larger than usual.

Holotype female, 8 mm. Eyes (relaxed) "freckled" as in *S. quadrivittatus*. Front taller than broad and a little divergent below; buff-gray pollinose not denuded at the ocellar hump, three prominent ocelli; callosity large, black with dark brown shades on the disc, shield-shaped like an ace of spades (as in some *Assipala*), a little taller than broad and widely separated from the eyes, the apex nearly reaching the anterior ocellus and connected to it by a thin black line. Face and cheeks buff-gray pollinose, the beard sparse and concolorous; two large, irregular, black calli above the apodemal pits and divided by the sutures, but no lower median one between them as seen in most *quadrivittatus*. Antennae unusually robust and shaggy

with coarse black hairs; scape and pedicel reddish darkening apically, the former a little over twice longer than the pedicel and over two thirds as long as the front; flagellums black, reddish at the extreme base, the apical annulus missing on each, plates with prominent pseudannulations. Palpi slender, dark red, the basal segment brown, no lateral furrows.

Body gray with faint buff tints on the dorsum, notum with four dull darker lines, the two submedian ones joined in front of the scutellum, and abdomen with four rows of large blackish dashes and spots on the anterior margins of the tergites, but no sublateral spots on tergite 2. Vestiture mostly pale, straw yellow. Legs reddish, darker at the apices of the femora, tibiae, and tarsi. Wings smoky, especially beyond and below the stigma; spots prominent and distributed about as in *S. quadrivittatus* but without sub-

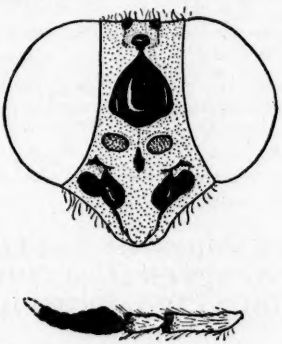

Fig. 1. *Silvius gibsoni*, n. sp. Head and antenna.

marginal ones on veins R_5 and M_2, the mesal one on vein R_{4+5} almost as long as the stigma, a large spot confined to the base of cell M_1 and neither extended along the veins nor connected across the base of cell M_2 to a faint shadow at the base of vein M_3 (at lower outer corner of the discal cell) as in *sayi*. Halteres blackish brown. Subepaulets bare.

The type was taken at Monterrey, Nuevo Leon, Mexico, on April 2, 1957, by V. Espinosa. In U. S. National Museum through courtesy of Dr. William W. Gibson of the Rockefeller Foundation's Agricultural Program in Mexico for whom the species is cordially named.

In some respects this species is intermediate between *S. sayi* Brennan and *S. quadrivittatus* subsp. *texanus* Pechuman. It differs from the former in having three submarginal spots, the internal ones not confluent, and sublateral as well as submedian rows of abdominal spots. Reduction of the submarginal wing spots to three, lack of confluence of spots behind the stigma, and restriction of spot at apex of the discal cell to the base of cell M_1 (not including M_2), distinguish this from *texanus*. In addition, the much larger frontal and facial calli with no median one between them below and the more robust antennae, separate this from both the above species. As Pechuman (1938) has pointed out, only occasional *quadrivittatus* lack a small median, facial callus.

SUMMARY

The following Tabanidae are described as new: *Dichelacera (Psalidia) beameri* (holotype male from Morales, Mexico), *Stenotabanus stonei* (holotype female from Chiapas, Mexico), *Hybomitra beieri* (holotype female from São Paulo, Brazil), *Tabanus barrettoi* (holotype female from Pernambuco, Brazil), and *Silvius gibsoni* (holotype female from Nuevo Leon, Mexico). New synonymy includes: *Stenotabanus furvus* (Hine) antedates *S. maculipennis* (Krober), and *"Stypommia" anachoreta* (Philippi) equals *Agelanius meridianus* Rondani.

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TRANSPLANTATION OF INTEGUMENTAL TISSUE AMONG SEVERAL SPECIES OF COCKROACHES (BLATTIDAE:ORTHOPTERA)[1]

GREGORY B. MULKERN[2] AND FRED A. LAWSON[3]

This study is a portion of a broad program investigating dimorphism in cockroaches. Integumental tissue was transplanted among several species of cockroaches to determine possible interspecific effects of the host environment on the transplanted tissue.

Wigglesworth (1936) caused decapitated *Cimex* and *Triatoma* nymphs to molt by joining them in parabiotic fusion to intact *Rhodnius* nymphs, thus indicating that the hormones connected with molting and metamorphosis were not specific in action. The same author (1940) caused adult tissue to undergo further molts by implanting it within nymphs of the same species. Bodenstein (1953) transplanted integumental structures among various instars of *Periplaneta americana* (L.). Nayar (1954) induced larval lepidopteran skin to transform directly to the adult state by transplanting it into late pupal integument.

[1] Contribution No. 691, Department of Entomology, Kansas Agricultural Experiment Station, Manhattan. The investigation was supported in part by research grant No. RG-4141 (C) from the National Institutes of Health, Public Health Service.

[2] Portion of a dissertation presented as partial fulfillment of the requirement for the degree Doctor of Philosophy in Entomology at Kansas State College.

[3] Graduate Research Assistant and Assistant Entomologist, respectively.

MATERIALS AND METHODS

Except where adult tissue was transplanted, all cockroaches used in these experiments were operated within the first two days of the post-ecdysial period. The use of newly molted animals insured sufficient time for recovery from the operation before the start of the next molting sequence and, also, made certain that the transplanted tissue would be in approximately the same stage of the molting cycle as was the host tissue. Since adult tissue is stable in regard to molting, age was not considered when adult donors were used.

For a transplanting operation, a specimen was anesthetized with CO_2 and placed dorsal side up in a shallow wax-filled glass dish. Paper strips were laid over the body and sealed to the bottom with a warmed glass rod. The pronotum was exposed by removing those portions of paper that covered it. From the pronotum a small plate was cut out with a fine scalpel. After internal attachments were severed, plates were quickly exchanged between two cockroaches. Each transplanted portion was usually placed so that a small portion could be inserted under the cut edge of the pronotum of the recipient. The size of the plate varied from operation to operation. In general, the larger the piece of tissue transplanted, the greater the instance of success. However, the larger the cutout area, the more likely it became that the esophagus or crop would expand and protrude through the opening. Throughout and following the operation, the wound area was washed with a saline solution of penicillin in an attempt to prevent infection from developing. These cockroaches were released and kept in isolation jars. Operated controls which had a plate removed but nothing transplanted were used for comparison with the experimental animals.

RESULTS

Transplantations were attempted between individuals representing 11 genera and 5 subfamilies. The species were:

Pseudomopinae
- *Blattella germanica* L.
- *Supella supellectilium* (Serv.)
- *Ischnoptera deropeltiformis* (Brunn.)
- *Parcoblatta* sp.

Panchlorinae
- *Leucophaea maderae* (Fab.)
- *Pycnoscelus surinamensis* (L.)

Oxyhaloinae
- *Diploptera dytiscoides* (Serv.)

Blattinae
- *Blatta orientalis* L.
- *Periplaneta americana* (L.)
- *Eurycotis floridana* (Walker)

Blaberinae
- *Blaberus giganteus* (L.)
- *Blaberus craniifer* (Burm.)

A successful transplant was one which became incorporated into the pronotum of the host to such an extent that it produced new cuticle and molted along with the host. In all successful cases the transplant was clearly distinguishable from the host tissue. Such transplants were recognizable by their own specific characteristics of texture, setal arrangement, color, etc. The transplants also were compared with operated controls and with their own exuviae to check identifying features.

Successful transplanting operations were accomplished with all species used except *I. deropeltiformis;* only a few individuals of this species were

available and the supply was exhausted before a successful operation was accomplished. Adult tissue only was used in transplants from *Parcoblatta, Pycnoscelus,* and *Diploptera;* nymphal as well as some adult tissue was used from other species. All donor-recipient relationships, with the percent of success attained in each, are shown in Fig. 1.

In general, transplants within a subfamily became incorporated into the host more readily than did transplants between subfamilies. Transplants to *P. americana* were more successful than to any other species. With *Blaberus* and *Leucophaea* it was much more difficult; the blood of these two clotted more rapidly than it did in any of the others used in this experiment. Consequently, greater care in washing off excess and clotted blood had to be exercised in working with these genera.

The main reason for failure of a transplant was the normal wound healing action. When a wound disrupts the continuity of the integument, blood coagulates and forms a covering over the wound; by enlargement, mitosis, and migration of the cells a new epidermis is formed and a new cuticle is then secreted. (Cf. Yeager et al., 1932; and Wigglesworth, 1937, 1952.) When a piece of pronotal tissue was transplanted, the recipient's blood in many cases coagulated underneath it. The transplant then was sealed off by normal wound healing action. It appeared that in some experiments blood of the donor coagulated on the transplant before it was placed in position on the recipient and that the cells of the transplant died because they were prevented from coming in contact with the blood of the host. Transplants which had been sealed off in these ways usually became dark and opaque with the setae brittle and easily broken. When the molt occurred, the unincorporated tissue was sloughed off with the exuviae and the wound area of the host was covered with new cuticle of its own type. The cuticle covering the wound area was usually devoid of setae or characteristic texture and

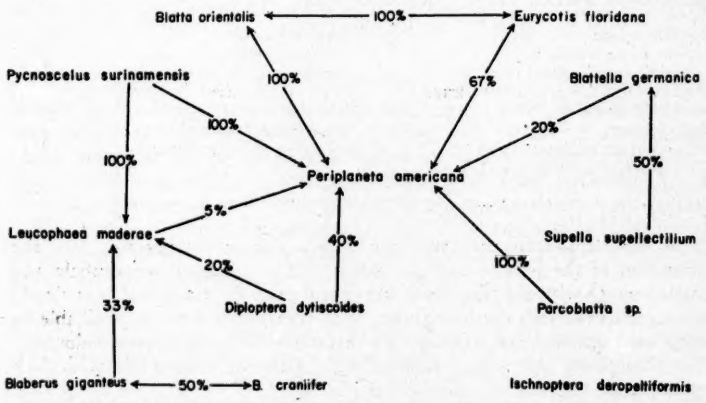

Fig. 1. Diagram of cockroach donor-recipient relationships in cuticular transplant experiments. Arrows point to recipients. Percentage of success in each case is given.

often color. These were similar to the controls in which a plate was removed and nothing was transplanted to cover the wound.

After molting, the exuviae of a successfully transplanted piece of tissue was composed of a normally thin, somewhat transparent exocuticle. After the first molt the transplant was nearly always smaller than was the original piece of tissue, because the edges apparently died and left only the center portions surviving. The transplanted tissue grew very little in size. Even after three molts, in which the host had grown considerably, the transplant was little if any larger. There was a tendency for the host tissue to expand into the operated area, and in some cases to displace the transplanted integument.

After molting, integumental tissue transplanted intraspecifically retained specific characteristics, such as setal arrangement, texture, and color. It was found that most intraspecific transplants were, after the first molt, lighter than their normal species color. With each successive molt they became still lighter, even though setal arrangement, texture, and ecdysial lines remained constant.

DISCUSSION

Integumental patches from nymphs and adults were successfully transplanted among several species of cockroaches. Synchronous molting with the host is further evidence that the molting hormones are not specific in action. It was also demonstrated that adult cockroach tissue is competent to undergo additional molts. An interesting point was the lack of pigmentation in the interspecific transplants. It was noted that, in such cases, the transplanted tissue was lighter than its normal color after the first molt and became still lighter with each additional molt. Except for the lack of normal coloration the transplants retained such characteristics as texture, thickness, and setal arrangement. According to Richards (1951) the epidermal cells secrete the molting fluid and new cuticle; pigmentation, however, is thought to be due to enzyme systems in the blood which act upon one or more substrates diffused throughout the cuticle.

SUMMARY

Integumental tissue was transplanted among members of 11 genera representing 5 subfamilies. Both nymphal and adult tissues were used. Certain variations in success of transplanting were noted. In general there was a somewhat greater instance of success in transplanting within a subfamily than between subfamilies. Intraspecific transplants developed normally and retained all specific characteristics including color. Interspecific transplants developed normally except that after the first molt the transplanted tissue was usually lighter in color and became still lighter at each successive molt. It was concluded that (1) the factors affecting molting and formation of a new cuticle are non-specific but that (2) the factors effecting pigmentation are specific.

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THE GENUS *TARSONEMELLA* HIRST, WITH DESCRIPTION OF A NEW SPECIES (Acarina, Tarsonemidae)[1]

ROBERT E. BEER

In 1923 Stanley Hirst described the subgenus *Tarsonemella* to accommodate in the genus *Tarsonemus* his somewhat anomalous new species, *Tarsonemus (Tarsonemella) africanus*. This species was especially curious because the pedicellate pseudostigmatic organs, normally occurring on all species in the family Tarsonemidae, were missing. An additional morphological anomaly was the peculiar structure of the front legs, which bore a striking resemblance to these appendages in certain species in the related families Scutacaridae and Pyemotidae. Due to the fact that most female mites in the family Tarsonemidae were found to be remarkably similar in general body design, Beer (1954) felt that the inclusion of *Tarsonemus (Tarsonemella) africanus* in the family was untenable and left the familial assignment of the species undecided. It has been my recent good fortune to have had the only known specimen of *T. africanus* examined critically for me by two mite specialists, Dr. G. Owen Evans and Dr. N. Shankarnarayan. This specimen is in the British Museum (Natural History) and is a very good slide preparation. Both Dr. Evans and Dr. Shankarnarayan reported that Hirst's original description and figures of the species are quite illustrative of the specimen with only two minor discrepancies noted.

In recent months a collection of mites that show distinctive affinities with *T. africanus* has come to my attention. With the additional light that these specimens have thrown on the taxonomy of the Tarsonemidae, I shall elevate Hirst's subgenus *Tarsonemella* to generic rank and redefine the genus so as to accommodate the two species.

[1] Contribution No. 1003 from the Department of Entomology, University of Kansas, Lawrence.

Genus *Tarsonemella* Hirst, 1923

Similar to *Tarsonemus* but tibiotarsus I of female subtending a stout, strongly recurved claw the base of which is recessed in truncated apex of tibiotarsal segment. Except for large claw, pretarsal elements of leg I greatly reduced or absent.

Type of genus: *Tarsonemus (Tarsonemella) africanus* Hirst (by original designation).

Location of type of *T. africanus:* British Museum (Natural History); a single specimen on microslide.

Tarsonemella beameri, n. sp.

FEMALE. Body robust, broadest at mid-length. Pseudostigmatic organs prominent, their ovoid apical expansions slightly longer than the slender pedicels. Apodemes prominent, the anterior median apodeme extending from V-shaped juncture of apodemes I almost to the strong transverse apodeme; apodemes II not quite reaching median apodeme; apodemes III especially strong but weakest just before reaching posterior median apodeme. Dorsum of propodosoma composed of two distinct areas, the small, triangular rostral shield located anteriorly being distinctly separated from the large propodosomal shield by a suture. Rostral shield with a prominent seta at each posterolateral angle. Main propodosomal shield with a pair of long setae, each as long as leg II. Hysterosoma with six distinct segments dorsally; first segment with two pairs of dorsal setae, the dorsolateral pair slightly longer than the dorsals; second segment without dorsal setae; third segment with one pair of long setae; fourth segment with two pairs of dorsal setae, the inner pair about one third as long as outer pair; fifth segment with one pair of long setae; sixth segment without dorsal setae. Ventral propodomal setae all of moderate size and of same length; setae of first pair situated slightly laterad from Y-shaped juncture of apodemes I and median apodeme; second pair of setae slightly behind apodemes II at their mid-lengths. Two pairs of setae situated near apodemes III, these setae arranged transversally, their lengths about equal. One pair of setae situated on apodemes IV at points about one third the distance from base of apodeme at coxa IV to anteromesal point of juncture with median apodeme. One pair of setae located near inner apical angles of coxae IV. One pair of setae directly behind the coxa IV ventrals and separated from those by a distance equal to length of seta. One pair of setae situated near apex of hysterosoma. All ventral setae about the same size except apical opisthosomals, which are slightly longer than others. *Capitulum:* Subcordate, slightly longer than broad, posterior margin rounded truncate; length including projecting palpi, 32 μ; greatest width, near base, 28 μ. Dorsal setae slightly shorter than ventrals, both pairs projecting forward to tips of palpi. Palpi short and stout. Chelicerae needlelike, cheliceral sheath without striae. *Legs:* All legs robust, anterior pairs about equal in length but legs I not tapering from base to apex as legs II. Leg I with unmodified, simple setae distributed as follows: femur with one very long and one short ventral seta, one dorsal seta; genu with two dorsal and two ventral setae; tibiotarsus with one very long dorsal seta near base of segment, two dorsals

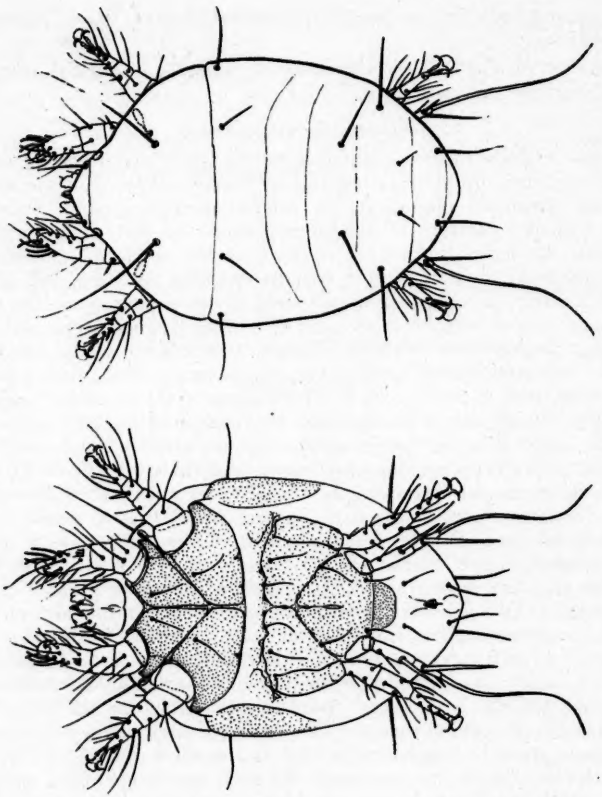

PLATE I

Tarsonemella beameri, n. sp., female. Dorsal and ventral views.

with acuminate tips, four dorsals with bluntly rounded tips, six ventrals with acuminate tips, one ventral with blunt tip. Modified setae of leg I as follows: femur with one stout lanceolate seta tapering from broad base to acuminate tip, located dorsally near outer margin; tibiotarsus with one stout lanceolate annulated seta located dorsally near outer margin at about mid-segment, one dorsal rodlike seta near base of segment on outer margin, one clavate seta adjacent to rodlike seta, one spinelike seta adjacent to clavate seta. Leg I bearing a large strongly curved claw; other pretarsal elements lacking. Leg II tapering from broad base to narrow apex of tarsus. Simple setae of leg I distributed as follows: femur with two short dorsals, one long ventral; genu with one dorsal, two ventrals; tibia with one long dorsal, two long ventrals; tarsus with two dorsals, two ventrals. Modified setae of leg II distributed as follows: tibia with one stout lanceolate seta tapering from broad base to acuminate apex, located on inner margin at mid-segment; tarsus with one very stout lanceolate seta tapering from broad base to acuminate tip, located dorsally near outer margin at mid-segment, one lanceolate seta on inner apical margin, one clavate seta with acuminate tip, its apical half annulated, located dorsally near base of segment. Leg II

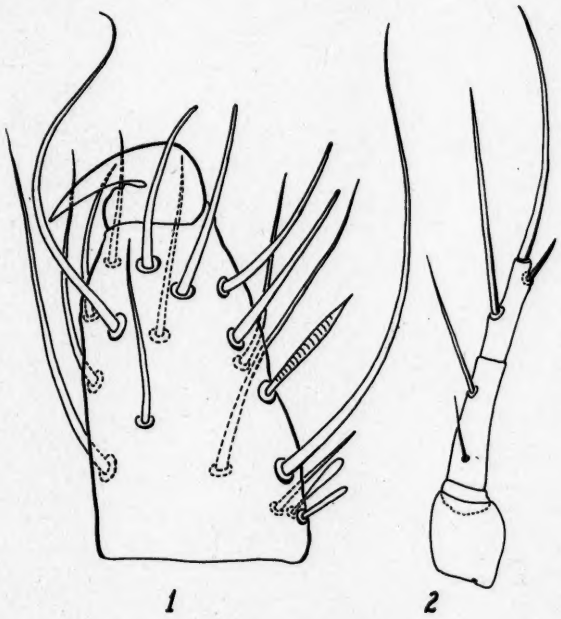

PLATE II

Tarsonemella beameri, n. sp., female. Fig. 1, Tibiotarsus I, dorsal aspect. Fig. 2, Leg IV, ventral aspect.

terminating in a narrow pretarsus that subtends two strong curved claws between which lies a broad empodium. Leg III with simple setae distributed as follows: femur with one dorsal, four ventral setae; tibia with one dorsal, three ventral setae; tarsus with one dorsal, three ventral setae. Leg III with pretarsal elements as in leg II. Leg IV with two ventral setae on femur, the proximal seta two thirds as long as segment, distal seta as long as segment; tibiotarsus with three setae, one twice as long as segment located ventrally on outer margin near mid-segment, one seta one half as long as segment located dorsally near inner margin slightly before tip of segment, one seta about five times as long as segment located at apex of segment.

Measurements: Tips of palpi to apex of opisthosoma, 221 μ; tips of palpi to main body suture, 79 μ; greatest width of body, 158 μ.

Holotype: Female, Saipan, Marianas Islands, November 14, 1947, W. H. Lange, from the beetle, *Brontispa mariana,* on a coconut palm, *Cocos nucifera.*

Paratypes: Seven females with same data as holotype.

Location of types: Holotype and four paratypes deposited in the Snow Entomological Museum, University of Kansas. Three paratypes deposited in the United States National Museum, Washington, D.C.

This species is named to honor the late Dr. Raymond H. Beamer who contributed a great deal to the growth and development of the Snow Entomological Museum at the University of Kansas and who was my good friend and colleague.

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CONTENTS OF THIS NUMBER

Raymond Hill Beamer by H. B. Hungerford 57
Concerning a Rabbit Cuterebrid, the Larvae of which May Penetrate the Human Skin (Diptera, Cuterebridae) by Lawrence R. Penner .. 67
Beamerella and *Kaaia*, Two New Genera of Chiggers from South America (Acarina, Trombiculidae) by James M. Brennan 71
A Review of the Genus *Neosophira* Hendel (Diptera, Tephritidae) by D. Elmo Hardy 76
New Records, Synonymy, and Species of Texas *Culicoides* (Diptera, Heleidae) by Robert Henry Jones and Willis W. Wirth 81
The Discovery of *Orthopodomyia signifera* (Coquillett) and *Anopheles barberi* Coquillett in Minnesota (Diptera, Culicidae) by Roger D. Price and Leo R. Abrahamsen 92
Effect of Feeding of the Four Biotypes of Corn Leaf Aphid on Susceptible White Martin Sorghum and Spartan Barley Plants by M. D. Pathak and Reginald H. Painter 93
A New Species of *Hysteropterum* from Grape (Issidae, Fulgoroidea, Homoptera) by Kathleen C. Doering 101
Notes on the Biology of a Mud Egg-case Making Fulgorid, *Hysteropterum beameri* Doering (Homoptera, Fulgoridae) by Evert I. Schlinger 104
A New Species of Rake-Legged Mite from Missouri (Acarina, Caeculidae) by Wilbur R. Enns 107
Two New Genera of Gerridae (Heteroptera) with the Description of a New Species by Herbert B. Hungerford and Ryuichi Matsuda 113
The Alimentary Canal of the Adult of *Tribolium castaneum* Herbst (Coleoptera, Tenebrionidae) by R. N. Sinha 118
Remarks on the Genus *Zercon* C. L. Koch, with Descriptions of Two New Species of the Genus *Prozercon* Sellnick (Acarina, Zerconidae) by Max Sellnick 125
Observations on the Behavior of Brazilian Halictid Bees II: *Paroxystoglossa jocasta* by Charles D. Michener and Rudolf B. Lange 129
A Comparative Study of the Foregut of Several Aquatic Hemiptera by Edwin P. Marks 138
The *Theodora* Group of *Acronicta* Ochsenheimer and a New Name for *Anytus* Grote (Lepidoptera, Noctuidae) by E. L. Todd 154
Faunal Affinities of Arizona *Phyllophaga* with Notes and Descriptions of New Species (Coleoptera, Scarabeidae) by Milton W. Sanderson 158
The Genus *Bonzia* in the New World (Acarina, Cunaxidae) by Warren T. Atyeo 173
Five New Species of Tabanidae (Diptera) from Mexico and Brazil by Cornelius B. Philip 177
Transplantation of Integumental Tissue among Several Species of Cockroaches (Orthoptera, Blattidae) by Gregory B. Mulkern and Fred A. Lawson 184
The Genus *Tarsonemella* Hirst, with Description of a New Species (Acarina, Tarsonemidae) by Robert E. Beer 188

. 57
. 67
. 71
. 76
. 81
92
93
101
104
107
113
118
125
129
138
154
158
173
177
184
188